Work Zone Safety and Mobility Manual

MDOT
Michigan Department of Transportation

Glossary of Acronyms

AADT	Annual Average Daily Traffic
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
BTP	Bureau of Transportation Planning
BTP/PPS	Bureau of Transportation Planning/Project Planning Division/Project Project Planning Section
C&T	Bureau of Highway Operations/Construction & Technology Division
CAADT	Commercial Annual Average Daily Traffic
CO3	Construction, Congestion, Cost Software
CS	Control Section
DHV	Design Hour Volume
DUI	Driving Under the Influence
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
HCM	Highway Capacity Manual
HOV	High Occupancy Vehicle
IDR	Inspector's Daily Report
ITCP	Internal Traffic Control Plan
ITS	Intelligent Transportation System
LCCA	Life Cycle Cost Analysis
LOS	Level Of Service
MDOT	Michigan Department of Transportation
MITS	Michigan Intelligent Transportation System
MMUTCD	Michigan Manual of Uniform Traffic Control Devices
MOT	Maintenance Of Traffic
MPH	Miles Per Hour
MPO	Metropolitan Planning Organization
NHI	National Highway Institute
PAP	Performance Assessment Plan
PCMS	Portable Changeable Message Sign
PIP	Public Information Plan
POB	Point Of Beginning
POE	Point Of Ending
PR	Physical Reference
PTR	Permanent Traffic Recorder
RPA	Regional Planning Agency
RTF	Rural Task Force
SMPT	Safety and Mobility Peer Team
TMIS	Traffic Monitoring Information System
TMP	Traffic Management Plan
TMS	Transportation Management System
TOP	Traffic Operations Plan

TSC	Transportation Service Center
TTCP	Temporary Traffic Control Plan
V/C	Volume to Capacity
VPH	Vehicles Per Hour
VPHPL	Vehicles Per Hour Per Lane
WZCZ	Work Zone Clear Zone

EXECUTIVE SUMMARY

Specific processes, procedures and guidelines to support implementation of the policy are developed and communicated through the Work Zone Safety and Mobility Manual. This manual will also include methods for the analysis of crash data, mobility analysis, work zone training requirements by classification and work zone process review procedures. All projects will require that a transportation management plan be developed and implemented. For projects that are considered significant, those that exceed the mobility analysis thresholds, an in depth transportation management plan will be required.

A transportation management plan (TMP) consists of three primary components: (1) a temporary traffic control plan that addresses traffic safety and control through the work zone, (2) a transportation operations plan outlining strategies that will be used to mitigate work zone impacts, and (3) a public information plan containing strategies to inform those affected by the work zone impacts and the changing conditions. The appropriate provisions from the TMP and related pay items are to be included in the contract documents and project estimates. The TMP is to identify responsible parties for implementing the TMP provisions and for monitoring the safety and mobility aspects of the project. All MDOT employees must be committed to the goal of providing a work zone with the highest level of safety and mobility possible at each step of the project development and delivery process from concept and planning through construction and operations. All management staff is responsible for ensuring the policy is implemented, incorporated and sustained for safe and efficient travel in Michigan.

Variations from the policy and this manual may be considered, evaluated and incorporated into specific projects on a case-by-case basis with approval of the region engineer and the Chief Operations Officer.

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Chapter 1 Purpose

The Michigan transportation system is critical to supporting a vibrant economy by moving traffic and freight safely and efficiently. Growing congestion on many roads with an increased need to perform rehabilitation and reconstruction is resulting in complex challenges to maintain work zone safety and mobility. The Work Zone Safety and Mobility Policy and corresponding manual are being established to improve safety and mobility in work zones by reducing congestion and traffic incidents.

The policy supports and is in accordance with federal regulation 23 CFR 630, Subpart J, referred to as the Work Zone Safety and Mobility Rule, which requires a policy for the systematic consideration and management of work zone impacts on all federal aid highway projects across all stages of project planning, development, delivery and operations. The policy is in agreement with and does not supersede State Transportation Commission Policy 10015, dated September 25, 1996.

The process defined in the policy and this manual will apply to all state trunklines, regardless of the type of roadway or bridge facility.

The policy and this manual apply to construction, maintenance and permitted activity work zones. Each type of work zone is to be analyzed in the same manner to provide consistency for travelers in Michigan.

Chapter 2 Roles and Responsibilities

2.1 Planning

Roles: Prior to projects being included in the call for projects, pavement and bridge conditions are provided, by Bureau of Highway-Delivery, Construction & Technology Division (C&T) and Bureau of Transportation Planning (BTP), to region development staff. Region system managers evaluate region condition data, and consider funding targets and statewide goals by template category. Road and bridge segments are identified for potential projects based on condition, corridor needs, funding constraints, coordination efforts and initial significance. This information is used to develop the region five year program, considering needs, goals and funding levels.

When initial project concepts are proposed, early mobility discussions with other road agencies are initiated. Concurrently, project coordination discussions are started with other transportation agencies and stakeholders that may be impacted by the proposed Michigan Department of Transportation (MDOT) projects. At this point, detours and potential alternate routes during construction are identified, and coordination efforts are started to prevent (or minimize) local and state work on parallel or adjacent routes during the same time-frames. After this initial coordination effort, conceptual project schedules are discussed and will then be based on region budgets and needs.

If there are other MDOT or local projects being developed along the corridor or within the influence area of the roadway network around the project work, the overall traffic management plan should consider the impacts of this work as well. If specific conflicts are identified, the corridor and network should be analyzed for impacts to the safety and mobility of the users along the MDOT project, as well as adjacent local projects.

The public, metropolitan planning organizations (MPO), rural task forces (RTF) and regional planning agencies (RPA) shall be notified of the proposed five year program projects, as well as potential future projects, through various region and statewide forums and meetings during the development process.

Responsibilities: Proposed five year program information is initially discussed with local agency staff by region planners and system managers. More formal presentations are made to the public and local agencies by region and Transportation Service Center (TSC) staff, with the support of the Office of Communication, during the annual five year program approval process. Prior to any projects being proposed for inclusion in the five year program, the region and TSC staff will discuss issues pertaining to the trunklines with local agencies including maintenance items, mobility concerns, context sensitive aspects and other related issues. Once initial project schedules are proposed, region and BTP, Statewide Planning Division staff can begin early mobility discussions with other road agencies and affected local government units (cities, villages, townships, etc.) through the MPOs, RTFs and RPAs. Concurrently, region and/or TSC staffs are

responsible for project coordination discussions with other transportation agencies in the vicinity of proposed MDOT projects to identify potential detours and alternate routes during construction and to avoid conflicting local and state work on parallel and adjacent routes. If potential conflicts are noted, region staff may need to contact the Bureau of Transportation Planning, Project Planning Division, Project Planning Section (BTP/PPS) for assistance in determining the network influence area and scope of roadways impacted, for projects determined to be significant**.**

After initial coordination efforts and modeling of the impacts, preliminary project schedules are developed by region and TSC staff. It is the responsibility of the TSC staff to identify and propose mitigation activities for inclusion in the TMP in subsequent project development phases.

2.2 Scoping

Roles: Scoping is an early development function. At the time a road segment is being considered for possible improvements, safety and mobility impacts for the proposed project and corridor are to be analyzed. A capacity analysis shall be done for the existing condition once the preliminary project limits are determined. At a minimum, the existing capacity for peak and non-peak hours shall be determined for the selected project location. This analysis shall include determination of the existing volume to capacity ratio, the existing travel times and the current operating level of service (LOS). In addition, a base line crash analysis is to be performed. Capacity, travel time, and LOS will be estimated for the proposed project work-zone during construction and compared with the existing condition data.

The proposed project work types should be analyzed, assessing the various construction alternatives available for each work type, as part of the scoping process. Each work type and construction alternative will require a review of the appropriate temporary traffic control plan (TTCP), taking into consideration existing operational factors within the project limits. When the proposed work type is approved by the region, a project concept statement is developed. A capacity analysis and estimate of traffic diversions for the approved project work type and construction alternative must be completed. The results of the analysis are to be compared with the existing conditions for use in the development of the TTCP. Baseline maintenance of traffic costs are estimated and mobility issues are identified during the scoping process. The detailed scope will also include maintenance of traffic costs.

During the scoping phase, if the approved project capacity analysis yields a volume to capacity ratio greater than 0.80, an increase in travel time greater than 10 minutes or the LOS drops below the threshold outlined in the Work Zone Safety and Mobility Policy, the project is deemed “significant” and a transportation management plan (TMP) must be developed. The TMP for a significant project must include the concept for the TTCP, the transportation operations plan (TOP) and the public information plan (PIP) in enough detail so that a reasonable cost estimate can be developed and included in the cost of the project scope. If there are other state projects being developed along the corridor or

within the network influence area around the proposed project, the TMP should consider these impacts. However, local schedules may not be known at this point. The influence area generally will include an area where traffic volumes on other roadways change by 10 percent or more as a result of the proposed MDOT work. Initially in MPO areas, "major" MDOT projects (significant projects over $10 Million or under $10 Million at the discretion of the region, TSC or BTP/PPS will be modeled to assess their impact on the network.

In an effort to reduce delay on significant projects, all reasonable mitigation measures should be assessed in an effort to keep the delay below the threshold limits. Potential mitigation techniques are identified in Chapter 5 in this manual. If these mitigation measures result in the TMP costs exceeding 25% of the project costs, the project shall be submitted to the Safety and Mobility Peer Team (SMPT) for review. A checklist in Chapter 17 can be used as a reference of the minimum items that must be assessed as part of the scoping process.

Responsibilities: The region/TSC is responsible for ensuring that the proposed project scope addresses work zone safety and mobility. TSC staff is responsible for developing the project level TMP, TTCP, TOP, and PIP for significant projects. The final scoping document shall include, at a minimum, the existing capacity analysis, the information used to develop a proposed TMP, the proposed capacity analysis using the preliminary TTCP and the cost estimates for the proposed TTCP components. This is done by region and TSC staff using the CO3 or comparable project level models as noted in Chapter 11.

During the scoping phase, if there are other projects being developed along the corridor or within the network influence area around this project, the region should ensure that the TMP takes these impacts into consideration. MPO or BTP statewide travel demand models can be used for corridor and network level impact assessment, to identify potential alternate routes and assess detour options. The BTP/PPS is to be contacted to coordinate network and corridor modeling for major projects and traffic data for all significant projects. For projects not requiring BTP/PPS modeling, region and TSC staff should refer to procedures in Chapter 3 of this manual.

If after all mitigation measures have been evaluated, the project still exceeds the threshold limits or the TMP costs exceed 25% of the projects costs, the region engineer and system manager should be notified. The region is then responsible for contacting the SMPT for a project review, and later approval by the Chief Operations Officer.

2.3 Development

Roles: The development phase continues with preliminary engineering activities being initiated for the project. The project scoping document should be reviewed to ensure that the project limits, the existing capacity analysis, capacity under construction analysis, LOS, baseline crash analysis and the proposed project fix type are accurate.

A detailed crash analysis should be completed for the normal roadway operation and for the various proposed construction staging options to ensure that crash patterns are not exaggerated. As the construction staging and existing operational factors are refined, the TTCP and its associated capacity analysis should be confirmed for its significance level. If the project level delay is confirmed to be significant using the preferred TTCP, a TMP shall be developed. TTCPs are developed for all projects. Mitigation measures must be considered for all significant projects and based on project level modeling using CO3 and BTP models from Chapter 11. In addition, these models are used to test the validity of assumptions, findings and proposed mitigation measures. The TOP shall include mitigation techniques developed for the geometric features, in an effort to reduce the delay below the delay threshold criteria for the given road, corridor and network. Based on the expected mobility issues, mitigation measures are selected and included in the project cost estimates. If detours are involved, discussions with affected local road agencies will occur at this time, including any proposed improvements needed for the detour route.

During the design phase, if other state and /or local projects being developed along the corridor or within the influence area of the project, the region should ensure that the TMP consider these impacts. However, local project schedules may not be determined until the year before construction. When MDOT schedules are finalized and local projects are known prior to construction, modeling is to be done to assess all corridor and network impacts for major projects. This will help to determine how all projects in an area interact with each other and affect overall mobility.

Region/TSC project development staff is encouraged to use TOP and PIP methods on major projects. The PIP shall be finalized based on the agreed to project scope, in coordination with the region communication representative, ensuring that project, corridor and network ramifications are considered. Project mobility issues are reviewed with the local transportation agencies, MPOs, RTFs, RPAs and local governmental units during annual region/TSC Transportation Summits, individual agency meetings or similar formats. Context sensitive solution issues impacted by mobility decisions are also reviewed during the design phase (also with project stakeholders and the public), based on the TMP/PIP.

Internal work zone traffic control plans are recommended to be developed for all TTCP in an effort to reduce conflicts between construction vehicles and motorists and to improve overall safety and mobility within the work zone. Project specific internal work zone traffic control plans should be developed as part of the construction staging plans, that clearly outline MDOT's expectation of the contractor including work zone access points, possible internal work zone haul routes and maintenance of the work zone devices. The constructability of the project should be discussed to ensure that the TMP, as developed, is in reasonable conformance with the expected construction sequence as outlined in the project progress schedule. If the refined TTCP and its associated capacity analysis are determined to be non-significant, the project design can proceed without additional delay analysis.

Responsibilities: The project manager is responsible for ensuring that the TMP complies with the requirements of the Work Zone Safety and Mobility Policy. The final TMP package will vary depending on the project's level of significance. Region/TSC staff is responsible for testing assumptions, findings and proposed mitigation measures using CO3, BTP models or similar tools. The project manager is responsible to ensure that the TSC traffic and safety engineer and the TSC delivery engineer have been involved in the project design process to ensure that a safety analysis and constructability issues are addressed in the development of the TMP and progress schedule.

In addition, the project manager is responsible to coordinate the completion of the PIP with the region communication representative. Region/TSC staff is responsible to ensure the TMP considers impacts when there are other projects being developed along the corridor or within the influence area of the roadway network around a given project. MPO or BTP statewide travel demand models are to be used for corridor and network level impact assessment for major projects. Region personnel are to contact the BTP/PPS for assistance with corridor and network assessments for all major projects. Region/TSC staff is responsible for reviewing and communicating project mobility issues with the local transportation agencies, MPOs, RTFs, RPAs and local governmental units. Context sensitive solution issues impacted by mobility decisions are also reviewed during the design phase with project stakeholders and the public, based on the TMP and PIP procedures, by region/TSC staff with support from Bureau of Highway Operations, Design Division staff as needed.

The region engineer and region system manager should be notified, if after all mitigation measures have been implemented, the project still exceeds the mobility threshold limits or the TMP costs exceed 25% of the projects costs. The region is then responsible for contacting the SMPT for a project review and approval by the Chief Operations Officer.

2.4 Delivery

Roles: Prior to start of the project, the constructability of the project should be reviewed to ensure that all parties, including local agency officials, understand the requirements of the TMP as it relates to the proposed construction sequence as outlined in the project progress schedule. The TMP should be checked prior to implementation to ensure that field adjustments are not required. Existing operational factors located within the project limits should be documented.

The TMP is to be discussed during the pre-construction meeting with the contractor to ensure that all aspects of the plan are understood by all parties prior to implementation. An internal work zone traffic control plan for the project is required from the contractor which clearly outlines internal haul routes, work zone access points and the maintenance of the work zone devices. The objective of this internal traffic control plan is to minimize conflicts between construction vehicles and motorists and to improve overall safety and mobility within the work zone.

Prior to the start of construction, local agency officials are to be contacted regarding construction schedules and coordination issues. The discussion should include a review of all aspects of the TMP to determine if any adjustments are necessary.

After initial implementation of the TMP, traffic delay monitoring, analysis and documentation are required during the life of the project. In addition, work zone crashes are to be documented and an analysis should be conducted to ensure that crash numbers have not been magnified. If monitoring of the work zone indicates that the actual delay times have exceeded the threshold limits anticipated or crash numbers have increased, adjustments in the TOP need to be considered. When traffic operations, either directly within the project or along adjacent routes within the network influence area, are not responding to the measures being implemented, changes need to be considered. Any changes made to the TTCP or the TOP for any stage of the project may result in the need for recalculation of the delay, volume to capacity ratio and LOS projections from the TMP. The cost and effectiveness of proposed TMP changes are to be evaluated based on the mobility policy threshold criteria and all cost modifications shall be communicated with the region system manager, before implementation.

A PIP shall be implemented for all significant projects, although, it is also recommended for non-significant projects. Public and stakeholders are to be notified of construction schedules and mobility mitigation techniques being implemented. On-going media updates for significant projects and/or stakeholder meetings for major projects help keep the public and stakeholders informed of construction progress, TTCP changes and other project status issues per the project PIP.

Traffic conditions in all construction project work zones should be monitored to verify assumptions and projections made during project development. Documentation of the findings and impacts of various techniques used to mitigate impacts will assist in the selection of mobility mitigation measures for future significant projects.

Responsibilities: TSC staff are to work with local agency officials on construction schedules, coordination issues, and to obtain any required local permits (such as noise variances, night work, etc.), prior to construction. The TSC delivery engineer is responsible for ensuring that all aspects of the TMP are in accordance with the Work Zone Safety and Mobility Policy during the construction of the project. This includes the monitoring, analysis and documentation of mobility criteria in the TMP and crash numbers once implemented. The cost and effectiveness of proposed MOT changes are to be evaluated by TSC staff and cost modifications (or scope change) communicated with the region system manager, prior to implementation. Regions are encouraged to contact the BTP/PPS for assistance with corridor and network modeling of proposed modifications to TTCP plans on major projects when needed and if time allows. Model results can be used to support project level findings, and determine impacts of proposed TTCP changes during construction and justify possible increased costs.

The TSC delivery engineer is required to contact the necessary region/TSC personnel if field changes are made and/or if funding requirement changes are requested. This

includes contacting adjacent regions/TSCs if the change could have a negative impact on other projects within the corridor or network. If a TMP fails to operate within the required mobility criteria thresholds and the region/TSC has made all reasonable attempts to adjust the TMP to meet mobility and safety criteria thresholds, the region shall request the assistance of the SMPT for review of the project. Public and stakeholder notification of construction schedules and mobility mitigation techniques being implemented will be provided by TSC and the region communications representative, consistent with the PIP. TSC staff may need to hold periodic stakeholder meetings to discuss project progress and identify any significant stakeholder issues during construction on significant/major projects. The region communications representative will help keep the public informed of progress and any TTCP changes on significant/major projects as established in the PIP.

2.5 Maintenance

Role: Each region shall develop maps of significant and non-significant routes for maintenance purposes. The level of significance will be determined utilizing the Work Zone Safety and Mobility Policy thresholds for routine lane closure operations. Once these routes are identified, each region is to develop a TMP for each of these routes to be used by all state and contract maintenance personnel. For all significant routes, an in-depth TMP shall be developed that includes a TTCP, a TOP and a PIP which comply with the policy thresholds. If a significant route TMP is unable to meet the policy threshold using a routine lane closure operation, mitigation measures need to be developed as part of the TOP as discussed in Chapter 5. Consideration should be given to the development and construction of full width, full depth shoulders on significant routes where routine maintenance operations will consistently result in the policy thresholds being exceeded. All maintenance operations shall be coordinated with other projects being constructed along the corridor or within the influence of the roadway network encompassing the project work. The TMP should consider the impacts of this additional work and may need to be altered accordingly. Work zone crashes shall be documented and an analysis should be conducted to determine if crash numbers have increased. After implementation, if the monitoring of the work zone indicates that the calculated TTCP delay criteria has been exceeded or crash numbers have increased, adjustments shall be made to the TOP in an effort bring the impacts within the allowable work zone safety and mobility threshold criteria.

On routes that are deemed significant, each region shall develop designated emergency management routes that can be used by local emergency management personnel during road closure events.

Responsibility: It is the responsibility of each region/TSC maintenance supervisor/coordinator to ensure that all state and contract maintenance activity is conducted in accordance with the Work Zone Safety and Mobility Policy. The development of the significant and non-significant route determination and the corresponding mobility analysis for each routine lane closure operation shall be completed by the region/TSC traffic and safety engineer. The coordination of projects between delivery and maintenance shall be the responsibility of the region/TSC

maintenance supervisor/coordinator. Work zone monitoring shall be completed by the region/TSC traffic and safety engineer.

2.6 Utility and Permits

This section is being reserved for a future update. Implementation of the Work Zone Safety and Mobility Policy for this section is not required until January 1, 2009.

2.7 Safety and Mobility Peer Team

Role: SMPTs will be established for development and delivery. The purpose of each team is to conduct independent reviews and/or inspections of projects and provide recommendations to the Chief Operations Officer on projects that are subject to his review and approval before implementation.

Development Safety and Mobility Peer Team

The team will consist of the following personnel independent from the Region where the project was developed:

- Region engineer (Chairperson)
- TSC manager
- Statewide work zone administrator
- Development engineer
- Delivery engineer
- Traffic and safety engineer/technician

The review would be conducted when project travel time delays, level of service or volume to capacity ratios exceed policy thresholds after all reasonable mitigation has been implemented or the cost to mitigate travel time delays, level of service or volume to capacity ratio below the policy threshold exceed 25% of the project cost.

The project reviews will be conducted monthly as needed. Region personnel are to contact the Statewide Operations Engineer in the Bureau of Highway-Delivery to request a development SMPT review. The review is to be requested after the Plan Review and prior to the Errors and Omissions Conference.

Delivery Safety and Mobility Peer Team

The team will consist of the following personnel independent from the region where the project is being constructed:

- Statewide work zone administrator (Chairperson)
- TSC manager

- Development engineer
- Delivery engineer
- Traffic and safety engineer/technician

The reviews/inspections would be conducted when the TMP has been implemented and the project is experiencing unexpected safety and mobility issues that exceed the policy threshold limits after additional mitigation efforts have been incorporated. The reviews/inspections will be conducted on an as needed basis. Region personnel are to contact the Statewide Operations Engineer in the Bureau of Highway-Delivery to request a delivery SMPT review.

Responsibility: It is the responsibility of each region to contact the Statewide Operations Engineer in the Bureau of Highway-Delivery if a SMPT review is needed. Each region shall submit six copies of the project TMP as outlined in Chapter 4 to the Statewide Operations Engineer at least 7 days in advance of the SMPT review meeting.

Chapter 3 Mobility Analysis

The following mobility analysis process will apply to all projects and related activities to determine to what extent work zone mobility impacts need to be further reviewed, mitigated, or approved. This process is critical and is to be commenced during the planning phase. This chapter outlines several ways to calculate volume to capacity (V/C), level of service (LOS) and travel time delay. The methods used in the examples are not the only way to calculate the mobility parameters. There are other Traffic and Safety Notes tables in 901A and 907A that are not highlighted in the examples that can be utilized to come to similar solutions. The examples highlight one way of performing the analysis but not the only way. There are also many software suites available that are available for use as discussed in Chapter 11.

During the planning phase, region/TSC staff will determine if a project is potentially significant or non-significant in relation to mobility impacts.

- Projects which are determined to be potentially significant require additional mobility analysis.
    - A traffic regulating operation project is to be considered significant if the work zone operations result in a user delay greater than 10 minutes.
    - A non-traffic regulating operation project is to be considered potentially significant if any of the following apply:
        - Any project that occupies a specific location for more than three days with either intermittent or continuous lane closures.
        - Any project that alone, or in combination, with other nearby concurrent projects is anticipated to cause sustained work zone impacts that are greater than what is considered tolerable. This will be based on an assessment of work zone safety and mobility impacts (volume/capacity, travel time, and level of service).
        - Any project defined as potentially significant or critical by region staff.
- Projects which are determined to be significant require the development of a transportation management plan (TMP) as discussed in Chapter 4.
- Projects which are determined to be non-significant also require a TMP, although, do not require additional mobility analysis.

All potentially significant projects are to be further evaluated for possible mobility impacts to the transportation system by being reviewed against the thresholds for the following critical evaluation criteria:

- Volume to Capacity: Threshold - greater than 0.80
- Travel Time: Threshold – greater than 10 minutes
- Level of Service: Threshold – lower than or equal to LOS D or, LOS C if the current operation is LOS A

Projects that exceed any one of the three evaluation criteria thresholds are considered significant and must have a project specific TMP developed and implemented. Mitigation measures to minimize travel delay are to be designed into the project. If any one of the thresholds is exceeded after the design of mitigation measures, region personnel are to contact the Bureau of Highway-Delivery, Statewide Operations Engineer to request a safety and mobility peer team (SMPT) review. The team will recommend, where appropriate, TMP improvements to the region engineer and the Chief Operations Officer. If mobility impacts are within each of the allowable thresholds after the design of the mitigation measures, the TMP is considered acceptable and review by the SMPT is not necessary.

Variations from the above thresholds may be considered, evaluated, and incorporated into specific projects on a case-by-case basis with review by the SMPT and approval of the region engineer and the Chief Operations Officer. Projects that do not exceed any of the three evaluation item thresholds prior to design of any mitigation measures are considered non-significant.

The process for determining whether a project is significant or non-significant is outlined in Figure 3.1 on the following page.

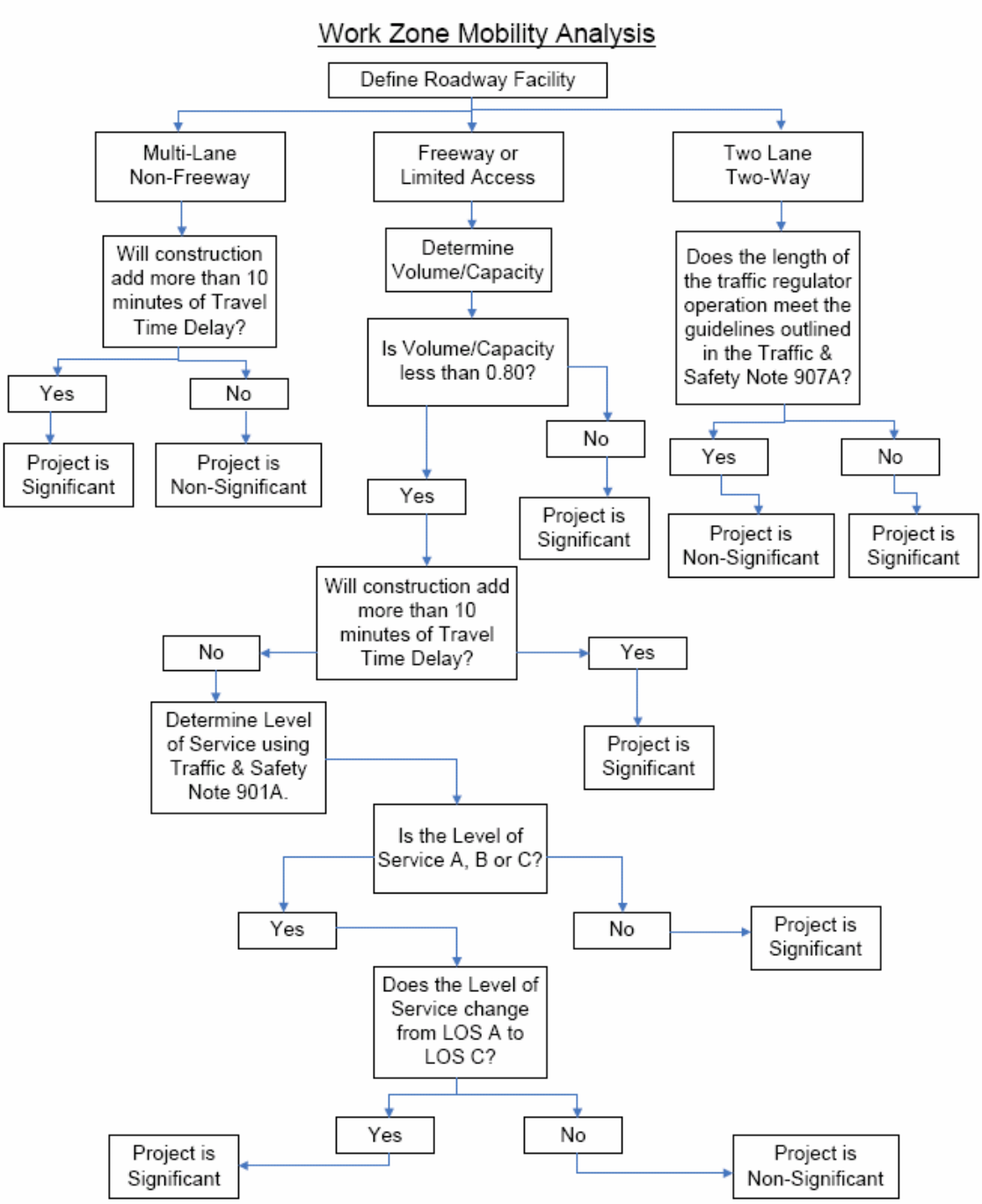

Figure 3.1 Work Zone Mobility Analysis Decision Tree

3.1 Volume to Capacity

The V/C ratio within a proposed work zone must be calculated. Volumetric data can be obtained during the preliminary phases of project development through BTP, Asset Management Division, Data Collection Section. Another source to obtain volumetric data is the Traffic Monitoring Information System (TMIS) found on the "connect MDOT" website. Under the MDOT drop down box, click on the Applications tab. Activate the TMIS under the Applications & Systems area within the Applications window. The counts used in the analysis should be the ones most recently taken.

V/C calculations are not required for signalized corridors or traffic regulating operations. V/C may fluctuate throughout a project based on variables such as the number of lanes and different posted speeds. User mobility in these two instances is more appropriately analyzed through the methods defined under travel time delay.

Once counts have been obtained, an analysis is to be completed utilizing the work zone volume and capacity values during a representative time of the work zone activity. Capacity can be estimated through the use of the following table from Traffic and Safety Note 907A:

NUMBER OF LANES		**AVERAGE CAPACITY OF AVAILABLE LANES**	
NORMAL	OPEN	VPH (vehicles per hour)	VPHPL (vehicles per hour per lane)
3	1	1400	1400
2	1	1550	1550
5	2	3200	1600
4	2	3400	1700
3	2	3400	1700
4	3	5250	1700

CAPACITY ADJUSTMENTS:

1. If the percentage of trucks is greater than 10 percent, reduce the VPH by 10 percent.
2. If an entrance ramp is within the closure zone, reduce the volume of the freeway lane by the minimum of either:
    a. Ramp entering volume in VPHPL, or
    b. 800 VPHPL
3. Add (or subtract) 10% of the VPH for above (or below) average work activities.
    a. Work activities which are in close proximity and/or involve larger equipment and numbers of workers would decrease capacity.
    b. Work activities which involve minimal noise and dust and are remote from open travel lanes would increase capacity.

Example:

A construction project is being planned to add a third lane in each direction of I-94 between US-131 and Oakland Drive in Portage. A determination needs to be made to maintain one-lane or two-lanes of traffic in each direction during the reconstruction and widening of the westbound lane. Commercial traffic is approximately 20% and two-way traffic will be separated from construction by a barrier wall.

Capacity for maintaining one-lane is approximately:
(1550 VPH) x (0.9 Commercial Vehicle Reduction Factor) = 1395 VPH

Capacity for maintaining two-lanes is approximately:
(3400 VPH) x (0.9 Commercial Vehicle Reduction Factor) = 3060 VPH

For the maintenance of one-lane of traffic, the volume equals 2975 vehicles per hour according to the traffic counts taken from 2:00 PM to 3:00 PM. The capacity equals 1395 vehicles per hour as determined above, so V/C = 2.13 as shown in the table below. This table represents counts taken during the four peak hours of the most heavily traveled day and the corresponding values of V/C.

Westbound I-94 between US-131 and Oakland Drive Friday, August 31, 2007				
Time		VPH From Counts	V/C 1-Lane	V/C 2-Lane
2:00PM	3:00PM	2975	2.13	0.97
3:00PM	4:00PM	3011	2.16	0.98
4:00PM	5:00PM	3179	2.28	1.04
5:00PM	6:00PM	2623	1.88	0.86

V/C values over 2.0 will cause undue congestion thereby negating the one-lane option. In this example a three lane option is not feasible due to right of way constraints, additional project costs, added mobility impacts for constructing the third lane and additional time added to the overall project. Based on the above information and analysis, construction will be maintained on two-lanes and the region engineer will be made aware of anticipated congestion during peak periods. One mitigation measure was to contract with a towing company to be on the job nearly twenty four hours a day, seven days a week, to rapidly respond to and clear incidents and non-recurring events.

The V/C threshold of 0.8 is exceeded in this example so it is considered a significant project and an in-depth TMP is required. Initial mitigation measures did not reduce the V/C ratio below 0.8, therefore, review of the project TMP by the SMPT is required. The SMPT is to make recommendations and suggest improvements to the region engineer and Chief Operations Officer.

3.2 Travel Time

The travel time delay is to be calculated for the work zone. If the work zone travel time delay is determined to be 10 minutes greater than the normal travel time for any given

point in the day, an in-depth TMP is required to be developed and implemented. Mitigation measures to reduce delay are to be designed into the project.

Example:

A construction project is being planned to add a third lane in each direction of I-94 between US-131 and Oakland Drive in Portage. Construction extends for approximately 2.6 miles. Estimated operating speeds can be found in Traffic and Safety Note 901A. The following table is given for a 70 MPH freeway and includes the speeds that were measured in the field during construction. An estimate of travel time delay needs to be derived from this information.

Level of Service	A	B	C	D	E
Operating Speed (Assume 60 MPH Work Zone Speed)	≤ 60 MPH	≤ 55 MPH	≤ 50 MPH	≤ 40 MPH	≤ 30-35 MPH
Measured Operating Speed	62.8 MPH	61.5 MPH	59 MPH	57.2 MPH	48.5 MPH

The predicted travel time delay process is calculated as described below. The Traffic and Safety Note 901A follows a straight line approximation; traffic hovers around the posted speed while LOS A to LOS C is experienced. Congestion begins to affect speed around LOS D and LOS E.

Predicted Travel Time Delay for the Peak Hour

From Traffic and Safety Note 901A, predicted delay can be calculated as follows:
[(Work Zone Length = 2.6 Miles) / (Speed at LOS E 35 MPH)] -
[(Work Zone Length = 2.6 Miles) / (Speed at LOS A 70 MPH)]
= 0.0371 Hours or 2.23 Minutes

The delay time in this example does not rise to the level of exceeding the allowable threshold, so no further action is necessary when considering travel time.

It is possible with utilizing measured operating speeds within various work zones to improve the predicted travel time delay for future projects, especially for those projects where traffic will operate at a Level of Service D or E. For the example described below, the measured travel time delay for the peak hour can be more accurately determined by using the operating speed measured as the project is underway.

Measured Travel Time Delay for the Peak Hour

The field measured operating speed can be used to calculate the actual delay:
[(Work Zone Length = 2.6 Miles) / (Speed at LOS E 48.5 MPH)] -
[(Work Zone Length = 2.6 Miles) / (Speed at LOS A 70 MPH)]
= 0.0165 Hours or 1 minute.

The measured travel time delay calculation can also be used to monitor delay times during construction and document operating conditions as discussed in Chapters 8 and 13.

Once the measured operating speed and V/C ratios are charted (see Figure 3.2), this information can be utilized for future travel time delay calculations within similar projects. This graph reports the actual (and now predicted) speed for each V/C ratio which can be used to calculate the future predicted travel time delay for similar projects. Another 2007 project involving a four lane freeway where one-lane in each direction was maintained by use of a crossover (I-94 just east of I-69) was measured for operating speed; a result of 44.2 mph was calculated for the V/C of 1 condition. This operating speed is far more accurate for a similar project than the Traffic and Safety Note's value of 35 mph.

It is recommended that major construction projects be spot checked with a vehicle and stop watch during peak periods. If further accuracy is desired and speed versus volume data is gathered during construction, a graph can be created to show the relationship of volume/capacity as it relates to speed which allows the calculation of travel time delay both in the actual and similar project future conditions.

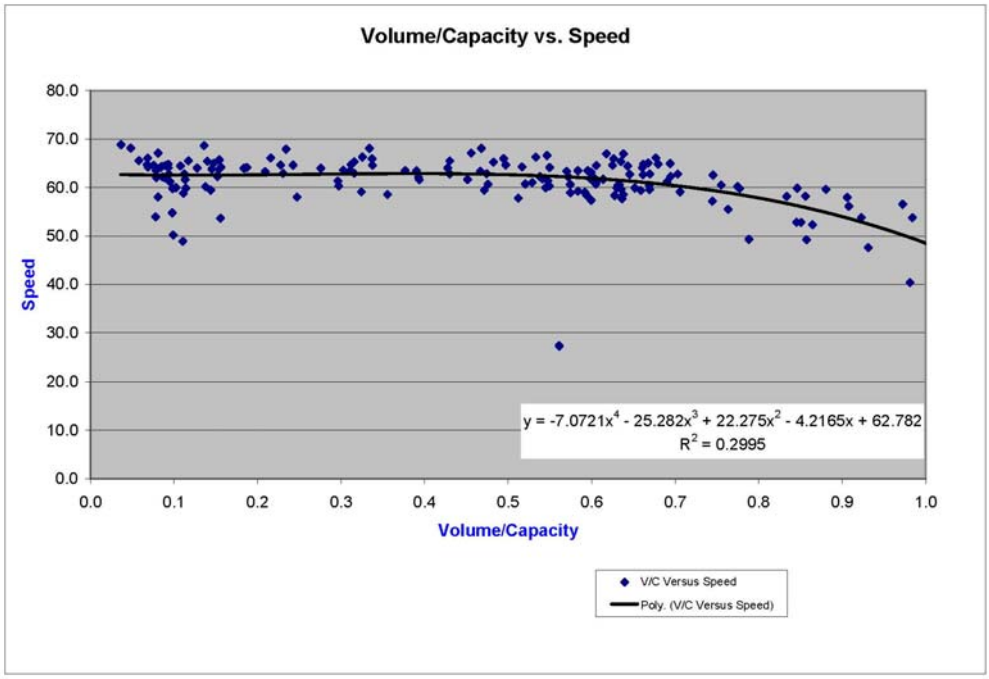

Figure 3.2 Volume to Capacity vs. Speed

The travel time method is the best way to analyze signalized corridors. In the case of a signalized corridor, a Synchro and SimTraffic analysis can provide a good estimate of travel time delay during construction. The travel time estimates can be checked by utilizing a vehicle and a stopwatch. Subtract the construction corridor travel time from the pre-construction corridor travel time. The Bureau of Highway-Delivery, Traffic and

Safety Division, Traffic Signal Unit is available to help with construction signal timing to mitigate delay.

An in-depth TMP is required when a calculated delay of greater than 10 minutes results. If the calculated delay remains greater than 10 minutes after delay mitigation is designed, the SMPT is to review the project's TMP. The SMPT is to make recommendations and suggest improvements to the region engineer and Chief Operations Officer.

3.3 Level of Service

The LOS is to be calculated for a proposed work zone based on the expected maintaining traffic conditions. If the calculated LOS is determined to be level D or lower or, LOS C is calculated and the existing facility currently operates at LOS A, an in-depth TMP is required to be developed and implemented. Mitigation measures to reduce delay are to be designed into the project.

It should be noted LOS calculations are not required for signalized corridors or traffic regulating operations. A level of service E for an unsignalized intersection corresponds to a user delay of 35-50 seconds and a level of service E for a signalized intersection corresponds to a user delay of 55-80 seconds. User mobility in these two instances is more appropriately analyzed through the methods defined under travel time delay.

LOS values can be found in Traffic and Safety Note 901A. The following table is given for a 70 MPH freeway:

Level of Service	A	B	C	D	E
Volume/Capacity	≤ 0.43	≤ 0.63	≤ 0.76	≤ 0.82	≤ 1.00

In the I-94 between US-131 and Oakland Drive project example, a level of service E during the peak hour is expected, therefore, an in-depth TMP is required. It should be noted that LOS E does not necessarily correspond to traffic coming to a halt. The LOS E with corresponding V/C of 1.04 had a field measured average speed of 45.2 MPH for that particular hour.

An in-depth TMP is required when a calculated LOS is less then or equal to D or when LOS C is calculated and the current LOS is A. If the calculated LOS remains less then or equal to D (or C if the current LOS is A) after delay mitigation is designed, the SMPT is to review the project's TMP. The SMPT is to make recommendations and suggest improvements to the region engineer and Chief Operations Officer.

3.4 Traffic Regulating

Traffic regulating operations are to be reviewed based upon a travel time delay evaluation. A traffic regulating operation is considered to be significant if traffic is delayed by more than 10 minutes.

An in-depth TMP is required when a calculated delay greater than 10 minutes results. If the calculated delay remains greater than 10 minutes after delay mitigation is designed, the SMPT is to review this project's TMP. The SMPT is to determine suggested improvements and make recommendations to the region engineer and Chief Operations Officer.

Example:

An 8 mile milling and resurfacing construction project is scheduled on a two lane two-way portion of M-37 in Barry County. Construction will take place at Control Section 08032 from beginning mile point 0.00 to ending mile point 8.00. The posted speed is 55 mph and will be dropped to 45 mph during construction.

Traffic count information for this location can be found on the "connect MDOT" website. Under the MDOT drop down box, click on the Applications tab. Activate the TMIS under the Applications and Systems area within the Applications window. TMIS states that the maximum Annual Average Daily Traffic (AADT) for control section 08032 MP 0.00 – 8.00 for 2006 is 10,356 vehicles for this segment. This number needs to be converted into design vehicles per hour.

Multiply the AADT by the Design Hour Volume (DHV) % to obtain the DHV. TMIS states the DHV% for this segment is 11%:

(10,356 vehicles) x (11% DHV) = 1139 Vehicles per Hour

Use the following table from Traffic and Safety Note 907A to determine the maximum allowable length of traffic regulation. A portion of the table is shown for purposes of this example.

CAPACITY IN TRAFFIC REGULATOR ZONES	
LENGTH OF TRAFFIC REGULATOR ZONE (MILES)	45 MPH POSTED CONSTRUCTION ZONE SPEED CAPACITY (VPH)
0.1	1163
0.2	1146
0.3	1128

The design hour has 1139 vehicles per hour. Utilizing the above table, a 0.2 mile traffic regulation operation will result in delays of 10 minutes or less (1139 is less than 1146).

The delay time in this example does not rise to the level of exceeding the allowable threshold, so no further action is necessary when considering travel time in this traffic regulation scenario.

Chapter 4 Transportation Management Plans

A transportation management plan (TMP) provides strategies, elements and details for managing project work zone safety and mobility impacts. A TMP is required on all projects and is to be commenced during the project scoping/development phase. The TMP is intended to be a dynamic document. Work zone safety and mobility impacts as well as transportation management strategies (alternative design, alternative contracting methods, etc.) that minimize these impacts are to be evaluated, documented, and recommended by project staff. Modifications are to be made to the TMP as a project progresses through the planning, design and construction phases when safety and mobility impacts are found to be different than anticipated. All modifications to the TMP are to be documented.

There are three major components to a TMP:

Temporary Traffic Control Plan (TTCP)
A TTCP is a common component for all projects and will contain information (plan sheets, details, special provisions, etc.) on how facility traffic will be maintained. This plan includes the specific traffic control devices, temporary pavement markings, and other such information that will assist travelers in traversing the work zone in a safe and efficient manner.

Transportation Operations Plan (TOP)
The TOP contains strategies to address the operations and management of the local transportation system that is affected by the project. Such strategies will include items such as work zone intelligent transportation system (ITS) components, law enforcement and incident management.

Public Information Plan (PIP)
The POP describes how project information will be communicated to affected parties, traveling public, and project stakeholders both prior to and during construction operations. The plan will also describe the most efficient method of communicating this information via local media, business groups, message signs and other such strategies.

The three components of a TMP described above are to be developed during the project scoping/development phase. Mitigation for work zone impacts should be planned, discussed and coordinated as early as possible in the design process. Any project which is determined to be non-significant does not require a TOP or PIP as part of the TMP, however, these plans should be considered for inclusion where appropriate. In summary:

- Significant Project – TMP
  - TTCP
  - TOP
  - PIP

- Non-significant Project – TMP
    - TTCP
    - TOP (not required, use if appropriate)
    - PIP (not required, use if appropriate)

The Federal Highway Administration (FHWA) is developing a guidance procedure for assessing performance of a TMP. The guidance procedure will be incorporated into this manual and all TMP's will be required to have a performance assessment plan.

4.1 Temporary Traffic Control Plan

TTCP's are the most critical part of the TMP as this is how the transportation facility will be maintained during construction operations. The TTCP will be the first engagement for numerous users of the transportation facility. Typical temporary traffic control plans are shown throughout Part 6 of the Michigan Manual of Uniform Traffic Control Devices (MMUTCD) and the MDOT Traffic and Safety Division Maintaining Traffic Typical Library. These resources provide the basic traffic control for project specific work zones. A substantial amount of work zones will require further development of these sample typical plans to address all project features. The TTCP should address maintaining traffic road/bridge typical cross sections, lane widths, lateral buffer and/or shy distances and edge drops created by construction staging.

The TTCP shall consist of the following items:

- MDOT Maintaining Traffic Typicals
- Special Provision for Maintaining Traffic
- Maintaining Traffic Pay Items
- Internal Work Zone Traffic Control Plan (contractor provided document)

The TTCP should include the following items as appropriate:

- Maintaining Traffic Plan Sheets
- Temporary Sign Details
- Temporary Pavement Marking Details
- Traffic Detour Sheets
- Temporary Signal Timing Permits
- Temporary Signal Staging Plans

Work zones for maintenance operations and permitted activities are to be controlled in the same manner as construction work zones as these operations are just as critical to safety and mobility on the transportation system. Consistency in Michigan work zones is critical for safety, mobility and efficiency for work zone personnel and the work zone motorist. In numerous instances these work zones are of immediate nature and planning time is severely limited. Staff involved with these operations must ensure that the appropriate maintaining traffic details, temporary traffic control devices, work zone requirements, and public communications are implemented to reduce work zone impacts.

The commencement of traffic pattern modifications and the initial placement of temporary traffic control devices is an extremely critical time for the work zone. This time also includes the traffic changes between stages of construction. Work zone safety and mobility is heavily impacted at these times. Additional planning for these events is to be considered and documented in the TTCP. As an example, project staff should document which days of the week and times of the day are the most conducive to altering or changing traffic patterns. This may reduce the impact of the initial traffic control changes and increase work zone safety.

TTCP elements may include the following features as determined by project staff:

- Complete Roadway/Bridge Closure
- Reduction in Lane Widths (to provide additional lanes)
- Shoulder Widening (to provide additional lanes)
- Lane Shifts (elimination of center left turn lane, etc.)
- Temporary Crossovers (maintain two way traffic on one bound)
- Reversible lanes (moveable barrier, signing, markings, etc.)
- Ramp closure(s)
- Intersection closures
- Night work
- Weekend work
- Weekday off-peak
- Hourly restrictions
- Turning prohibitions
- Signal timing modifications
- Pedestrian detour or accommodations
- Off-site detours/use of alternate routes
- Coordination Strategies
    - State projects in area - "corridor approach" to construction
    - Local projects in area
    - Local special events
    - Large traffic generators (arenas, stadiums, concert halls, shopping, schools, etc.)
    - Utility coordination
    - Railroad coordination
    - Permit coordination
- Contracting Strategies
    - Design/Build
    - A+B bidding
    - Incentive/Disincentive clauses
    - No-Excuse clauses
    - Lane rental
    - Ramp rental
    - Expedited Schedules

- Traffic Control Devices (Refer to Chapter 9 for usage statements for traffic control devices)
    - Temporary Signs
        - Warning signs
        - Regulatory signs
        - Guide/Information signing
    - Changeable message signs (both portable and static)
    - Lighted arrow panels
    - Channelizing devices (drums, "grabber cones", tubular markers)
    - Temporary pavement markings
    - Traffic regulators
    - Uniformed police officers for traffic control
    - Temporary traffic signals
    - Lighting devices for equipment or work zone
    - Temporary concrete barrier
    - Truck mounted attenuators
    - Temporary rumble strips

The TTCP elements listed above (or other elements determined to be appropriate) are to be used to mitigate safety and mobility impacts to the extent possible.

Pedestrian and bike facility conflicts must be addressed in the TTCP. Any construction activity conflicts are to be reviewed, documented and mitigated in the TTCP. The plan must provide detail that addresses the conflicts and ensures a temporary route is safe and adequate to meet the needs of the facility users. All temporary pedestrian facilities must be ADA complaint. Transit drop-off/pick-up locations and activities must be addressed with the transit agency including the possibility of temporary site relocation.

4.2 Transportation Operations Plan

The TOP includes strategies for operation and management of the work zone, adjacent network corridors and the facilities impacted by the work zone. These facilities include all relevant transportation modes (transit, roadway, freight, rail, air, non-motorized, etc.) which are impacted by the work zone operations.

One of the key components of the TOP is the proposed mitigation measures used on the project. In addition, the TOP is to include the proposed methodology for monitoring, measuring and documenting the safety and mobility impacts of the work zone during the life of the project. Examples of possible mitigation measures are as follows:

- Demand Management Strategies
    - Transit service improvements
    - Transit incentives
    - Shuttle services
    - Ridesharing/Carpool programs and/or incentives
    - Park and Ride promotion strategies

    - High Occupancy Vehicle (HOV) lanes
    - Ramp metering
    - Variable work hours
- Corridor/Network Management Strategies
    - Signal timing/coordination improvements
    - ITS (including real time work zone systems)
    - Temporary traffic signals
    - Off-site intersection improvements
    - Bus turnouts
    - Turn restrictions
    - Parking restrictions
    - Vehicle height/width/weight restrictions
    - Separate truck lane(s)
    - Reversible lanes
    - Dynamic lane closure system
    - Ramp closures
    - Coordination with adjacent construction sites
- Work Zone Safety Management Strategies:
    - Speed limit reductions/variable speed limits
    - Temporary traffic signals
    - Temporary traffic barrier
    - Moveable traffic barrier
    - Attenuators (impact and truck-mounted)
    - Temporary rumble strips
    - Warning lights
    - ITS
    - Courtesy patrol
    - Construction safety supervisors/inspectors
    - Traffic monitors/inspectors
    - On-site safety training
- Incident Management Strategies:
    - ITS
    - Courtesy patrol
    - Emergency responders coordination
    - Surveillance (closed circuit cameras, loop detectors)
    - Enhanced mile-post markers
    - Tow service patrol
    - Media coordination
    - Designated local detour routes
    - Contract support for incident management
    - Incident/emergency management coordinator
    - Incident/emergency response plan
    - Dedicated funding for police enforcement
    - Dedicated breakdown area
    - Contingency plans
        - Stand-by equipment

- Stand-by personnel

It should be noted that not all of these strategies will be applicable on every project. Other strategies may be considered to accommodate operations on specific projects.

The TOP shall also include the proposed methodology for monitoring and measuring mobility during the various stages of the active work zone. Monitoring and measuring activities may include actions such as work zone travel time monitoring, vehicle detection devices, temporary/permanent video systems, etc.

4.3 Public Information Plan

The Public Information Plan (PIP) is intended to create an organized and systematic process to communicate work zone information to the traveling public and respective stakeholders. The PIP will include public/stakeholder information, communications strategies, and methods of delivery. The communicated information should include items such as construction commencement dates/time, brief work description, staged traffic changes (dates, times, specifics, etc.), emergency events/accidents, etc. The most effective means and methods for delivery of project information to the affected groups should be discussed in the PIP. This will include descriptions of local papers and contacts, supporting businesses for posting of information, potential public meeting locations, local business groups for getting the word out, etc. These specifics are more appropriate to determine prior to construction activities and will establish relationships that will assist during project delivery. Potential communication methods are listed below.

- Media (newspapers, TV, radio, etc.)
- Lane closure web page (Drive Michigan)
- Changeable message signs (both portable and with ITS)
- Temporary motorists information signs
- Advanced global area signing
- Dynamic speed message signs
- Highway Advisory Radio (HAR)
- Web-based motorists information campaigns (project email listservs)
- Freight informational campaigns
- Stakeholder updates/meetings

Work in this section will need to be closely coordinated with MDOT Office of Communications staff from both the Lansing office and the regions. The regional communication representative should be an active member in the development and implementation of the PIP.

4.4 Performance Assessment Plan

Work zone safety and mobility is to be monitored, measured, and documented during the construction phase of each project to verify the mitigation measures and strategies are

performing as expected. This documentation will be the basis for the project specific performance assessment plan (PAP) and will include documentation of the traffic delays, travel times, queues, volumes, and associated information. The information will assist in the verification of data and if additional measures should be taken to amend the TMP. All traffic incidents (accidents, load spills, natural disasters, etc.) are to be immediately documented and analyzed to determine if work zone hazards have developed that require action. This documentation is to be maintained in the project files and will assist with performance measures as described in Chapter 13. The following items may be used to document project incidents and activities.

- IDR's (Inspector's Daily Reports)
- Evaluation reports
- UD-10 compilations
- Traffic Measuring Devices (loops, tubes, radar, etc.)
- Video Cameras
- Additional devices or methods

The following costs are to be monitored and documented during the planning, design and construction phases of each project.

- Implementation Costs
    - TTCP costs
    - TOP costs
    - PIP costs
- Itemized costs by pay item
- Funding sources
- Staffing and resource costs

The FHWA is developing national and project specific performance measures which will be documented, discussed, and addressed in the PAP. Additional information regarding performance measures will be provided in future updates of this manual.

Chapter 5 Mitigation Processes and Techniques

ll work zones create some level of traffic and safety impacts. Work zone impact mitigation strategies are an important component in the overall design of transportation projects. It must be recognized that different projects have different needs, and the same level of work zone mitigation strategies is not appropriate for every project. Work zone traffic management can account for up to 25% or more of project costs and can significantly impact the safety and mobility of workers and road users. These impacts must be identified, mitigated, and managed. This chapter provides the designer with relative guidance and direction in developing a comprehensive work zone design which includes a transportation management plan (TMP) that identifies safety and mobility impacts and details the mitigation measures taken to address those impacts.

Safety and mobility are primary work zone management strategy considerations. Other important factors that must be considered include project constructability, cost and time. Work zone management strategies are developed through a detailed analysis of all the relevant information and can be generally included in the following categories:

- Traffic volume/capacity data
- Traffic/user access issues
- Local and regional traffic impacts
- Project schedule/time (working days, work hours restrictions, critical work/material time, seasonal issues)
- Project site conditions
- Project work operations (access, hauling)
- Project purpose and features (road encroachment impacts)
- Safety assessment (workers, road users)

Traffic mobility, work type, and road user safety should not be compromised to facilitate a more effective construction approach, but should be given a high level of consideration that initiates construction alternatives and innovations. Construction needs to be accomplished while accommodating safety and mobility to the extent practical. Road work construction operations create conflict points with motorists and are disruptive by nature. These issues must be analyzed at a detailed level to make safety and mobility improvements. Every project must be reviewed for safety and mobility impacts and have these impacts mitigated in accordance with the Work Zone Safety and Mobility Policy.

Safety and mobility impacts are to be identified from a work zone assessment. These impacts are not restricted to the work zone location, but include the network influence area described in chapter 3. Adjacent or overlapping projects may also be impacted. Work zone management strategies are not limited to just on-site issues, but will also need to address the impacts to the network influence area. Some strategies may need to be justified as costs begin to escalate. A benefit cost analysis comparing road user costs to affected project costs can be useful. Safety benefits/costs are more difficult to quantify.

Safety and mobility impact mitigation strategies are presented in more detail throughout this chapter.

The Michigan policy on work zone safety and mobility ensures that all work zone impacts are appropriately identified, mitigated, and managed on a systematic basis. Work zone and traffic management design strategies should begin from a perspective of providing the highest level of safety, mobility, and constructability possible. A total road closure may be the best example of this approach. It would appear to provide the safest, most mobile and constructible work zone since workers and road users would be fully separated, exposed to far fewer hazards. Road users would not be delayed through a restrictive work zone, and construction could proceed without accommodating traffic. This may be a desirable starting point and may actually be feasible for some projects or work stages. Unfortunately, most projects would not be good candidates for this strategy for a number of reasons including a lack of alternate route capacity, lack of adequate detours, severe congestion throughout a widespread area and other traffic management and cost issues.

A more common and usually acceptable approach may be a mix of short-term closures and planned work stages, with work zones that positively separate and protect both workers and road users, while accommodating efficient work operations and traffic mobility. Some projects would benefit from efficiently staged and protected work operations instead of routine lane closures that close and open each day. Some projects may appear to have very few options or opportunities for innovation, but still need to have a strategy that addresses all impacts.

The following strategies may be useful to consider for mitigating impacts on construction projects. They are categorized into traffic maintenance strategies and work schedule/incentive strategies. Large complex projects may incorporate a number of these strategies.

Traffic Maintenance:

- Closures: full, partial, short-term, ramps, approaches, detours, alternate routes
- Overbuilding: beyond normal project needs to maintain additional traffic
- Flagging alternatives: automated flagger assistance devices, portable signals, lane shifts
- Staged traffic control: moving work operations or unlimited work operations
- Local road improvements: capacity improvements, signals modifications, widening, frontage roads
- Vehicle restrictions: combination of hours and vehicle type (trucks, oversize, local traffic)
- Temporary connections: ramps, offset intersections
- Internal traffic control plans
- Temporary access: road approaches, work zone access, ramps
- Work zone ITS traffic management: driver information, queue detection, demand management

- Public information campaign: media, highway advisory radio, portable changeable message signs
- Temporary median crossover detours: allows full work access to one-half of the roadway
- Temporary express lane: no access lane through the project
- Incident response patrols: delay reduction through quick response
- Law enforcement patrols: safety issues, speeding, DUI, aggressive drivers
- Emergency pullouts for disabled vehicles
- Intelligent transportation system (ITS) devices and strategies
- Temporary or permanent widening to maintain traffic
- Temporary crossovers in lieu of part-width construction activities
- Reduced length of work zone lane closures or impact area
- Movable barrier systems or contra flow activities
- Signal timing adjustments within the project work zone and/or alternate and detour routes
- Geometric improvements within the project limits or on alternate/detour routes (e.g. additional turn lanes, curb improvements, pavement markings

Work Schedule/Incentives:

- Accelerated work schedules: overall impact duration reduction
- Innovative bidding: incentives, A+B bidding, lane/ramp rentals
- Performance-based traffic control: contractor incentives for efficiency and safety
- Driver incentives: additional transit use, alternate route use
- Alternative bridge designs: super girders, falsework restrictions, temporary structures
- Nighttime/weekend work requirements
- Incentive/disincentive for early completion or open to traffic dates
- "No Excuse" project completion/open to traffic dates
- Restricted work hours (e.g., no work or lane closures from 4:00 p.m. to 6:00 p.m.)

It is also important to remember that there are practical limits to work zone strategies. Mobility and safety benefits that are relatively short term may not be practical if the implementation of that strategy offsets a significant portion of the benefit. Some projects may benefit from a wider review and discussion on possible work zone strategies, such as:

- Cost risk assessment
- Value engineering study
- Constructability study
- Industry plan reviews
- Work zone peer reviews
- Work zone strategy conference
- Traffic survey/study

Constructability is a key element in a successful work zone strategy. Issues of material selection, production rates, and work operation efficiencies have a direct tie to the feasibility of the strategy. A strong emphasis has been placed on this area and several successful strategies have been implemented including:

- Total short duration closures (weekend, week, or a combination)
- 72-hour continuous weekday closure
- 55-hour weekend closure
- 10-hour nighttime lane closures

These strategies use specific materials such as quick-curing concrete, accelerated work schedules, prefabricated structure components, on-site mix plants, etc., and are based on actual production rates. Work zone strategy development is a dynamic process and may be ongoing as project information and design features are developed during the development process through delivery. There may be many factors involved with strategy development and it is necessary to be well organized to make sure all the relative factors are identified and evaluated

A comprehensive table of work zone impact management strategies to consider in the development of TMPs and how to apply them are located in Section 4.0 and Appendix B of **Developing and Implementing Transportation Management Plans (TMPs) for Work Zones** which can be accessed at the following website:

http://www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

Chapter 6 Safety and Design Considerations

Project development personnel are to design safety into all MDOT work zones and safety considerations are to be addressed in all Transportation Management Plan's (TMP). These considerations are to include items such as edge drops, vertical/horizontal clearance, lane widths, etc. These considerations are to be evaluated when scoping and designing transportation projects.

Lane Transitions and Widths

Existing lane widths should be maintained during work zone operations. The following factors are to be considered when narrowing lanes or shifting traffic.

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Length of project
- Duration of the lane width reduction
- Roadway geometry
- Percentage of commercial traffic

Lane transitions, reduced lane width, and traffic control changes in conjunction with the proximity of temporary traffic control devices must be incorporated into the work area in a manner that does not result in an unexpected condition for the work zone motorists.

The minimum allowable lane width for low speed, low volume roadways is 10 feet. All other roadways should maintain a minimum lane width of 12 feet. Lane width reductions to 11 feet may be considered when a 12 foot lane cannot be designed.

Shy Distance and Buffer Zones

Shy distance is the distance from the edge of the traveled way (lane line) to the nearest roadside object or traffic control device or the width of the temporary shoulder. It is the distance in which a motorist will not perceive the road side object as an immediate hazard and will not alter the position or speed of their vehicle.

Lateral buffer zones provide additional space between the motorist and temporary traffic control devices, the work zone operations, equipment and materials. The temporary traffic control plan is to provide the lateral buffer zone or clearance dimension to be used during construction operations.

Longitudinal buffer zones are provided at the beginning of the work zone between the end of the temporary traffic control transition and the beginning of the active work area. The length of this buffer zone, dimensioned on maintaining traffic typicals, should be

portrayed on the temporary traffic control plan and verified as adequate. Longitudinal buffer zones are required when "Where Worker Present 45" signing is in use.

Work Zone Clear Zone (WZCZ)

The contractor's operations may be exposed to errant vehicles that may enter the clear area adjacent to the traveled way. A WZCZ plan is to be required of the contractor as part of the internal traffic control plan (ITCP) to address storage of equipment, employee private vehicle parking, storage/stockpiling of materials, etc. The WZCZ applies during working and non-working hours and will only apply to roadside objects introduced by the contractor's operations.

The WZCZ and buffer zone dimensions should be evaluated and increased where appropriate for horizontal curves, long downgrades, steep inclines and locations of high traffic volume.

Vertical Clearance

It is critical to maximize the vertical clearance on all construction projects. The project should maintain the existing vertical underclearance between the roadway and structures, utilities, signs, etc. Any reductions to the existing vertical underclearance are to be posted on the Active Permit Restriction Bulletin system and actively signed on the construction project. The local TSC permit agent will be able to assist with the posting of any reductions to existing underclearance.

Lane Edges

Abrupt lane edges (vertical differentials) are to be minimized, mitigated, or eliminated adjacent to the traveled lane. Anticipated vertical drop-offs are to be included in the project plans along with the requirements for warning the motorist. Section 812 of the MDOT Standard Specifications for Construction and the guidelines for longitudinal edge drops provide additional requirements for shoulders and vertical longitudinal joints while maintaining traffic. The project designer is to take these requirements into account when designing and developing the project staging and maintaining traffic plans.

Temporary Portable Signal Plans and Lighting

For temporary traffic signal installations, provide a temporary traffic control plan that includes sign locations, signal layout, temporary pavement marking locations, removal or modification of existing pavement markings, location in relation to the work operation and timing of the signal based on the operation and delay of traffic.

Temporary illumination plans are to be designed to accommodate the needs and work operations to ensure there will be no conflicts with construction operations.

Temporary illumination is recommended on the following projects:

- Multi-staged projects with lane shifts and restricted geometrics.
- Projects with existing illumination that must be removed as part of the construction operations.
- Road closures and detour alignments where grade and alignment are unusual or complex.
- Temporary ramp connections and signal locations.
- Construction activities that take place at night.
- Traffic flow is split around or near an obstruction, or split to maintain roadway capacity.

Detours and Alternate Routes

The project designer is to ensure that sign placement will fit the locations shown along the detour or alternate route and that the signing will not conflict with existing signs, driveways or pedestrian movements. Detours and alternate routes are to be reviewed for upgrades to existing signing, pavement marking and traffic signals. For detours of extended periods of time, consideration should be given to the adequacy of shoulders, lane widths, turning radius for commercial vehicles and structural pavement and enhancements made where needed. Considerations should be given to the detour or alternate route that limits the additional distance and travel time for vehicles. Project designers are to coordinate and discuss detours and alternate routes with local transportation agencies and affected parties to avoid conflicts with local projects and transportation needs. All existing restrictions (horizontal, vertical, weight) are to be evaluated on the proposed detour or alternate routes to ensure that traffic is not further impeded or restricted. Emergency services are to be provided access to the worksite at all times for any emergency related event within or adjacent to the work zone. Project designers should evaluate and discuss detour and alternate routes with emergency service providers (fire, police, ambulances, etc.) so that response times can be reviewed and taken into account.

Pedestrians and Bicycles

When existing pedestrian and signed bike routes are disrupted due to construction activities detour routes for these facilities are to be designed into the temporary traffic control plan. The plans must show enough detail to address conflicts and ensure the temporary route is safe and adequate to meet the needs of the user. All temporary pedestrian facilities must be similar to the existing facility to meet the requirements of Americans with Disabilities Act (ADA). Additional consideration must also be given to transit activities within the construction site. The project designer is to provide access for transit pickup and drop off or should discuss the potential temporary relocation of the transit site.

Freeway Ramps

If existing ramp traffic geometrics are required to be modified ensure that the proposed traffic patterns are similar to the existing geometrics. If ramp transitions are required to

be shortened or modified due to construction operations the amount of time for implementation of these changes should be minimized.

Advance Warning Signs
While it is not required for all projects, it is advisable to show the specific temporary sign locations on the plans or in the special provision for maintaining traffic. This effort during design will assist in providing more accuracy in the field to ensure proper placement of the sign and reduce the number of obstructions and conflicts.

Project Specific Signing
The project designer is to provide sign specifications and details for all special or unique project signing to assist sign manufacturers with requirements for non-standard signs (i.e. warning signs for motorcyclists where rumble strips may be encountered). The proper sign supports for each sign are to be selected to ensure the temporary sign meets the crashworthy requirements of NCHRP 350.

Temporary Median Crossovers
Temporary median crossovers are to be designed to the same requirements as permanent crossovers. If permitted, the project designer should strive to complete this design work and let the temporary crossovers as a separate project the season before the actual construction project. This advanced construction will allow a more efficient start-up and earlier completion of construction activities.

Shifting Traffic Lanes
Numerous projects shift traffic to all or part of the existing shoulders. Project scoping and design staff need to thoroughly inspect the existing roadway shoulders to ensure the pavement will be able to handle the expected traffic loading. Pavement cores should be taken and evaluated to properly gauge the existing shoulder depth. The condition and integrity of existing drainage structures may not be able to support the expected traffic loads. Existing rumble strips should be evaluated for proximity to wheel paths and filled where appropriate. These serve as a critical traffic issue to motorists utilizing the temporary traffic lane. Vertical and horizontal clearances should be evaluated on roadway shoulders in the same manner as the mainline roadway. Any objects within eight feet of the temporary travel path should be identified using object markers.

Shoulders
Existing lateral conditions and construction operations may generate a narrow shoulder while maintaining traffic. The project designer should evaluate the cost to pave additional shoulder width in these areas to improve work zone safety and mobility. A hot mix asphalt paving width of six feet may be the most economical width based on cost history and work capabilities. Where the paving cost is prohibitive or space is not available, the addition of warning devices, such as signs or drums, should be implemented. The decision to use signage versus drums will depend on the site characteristics and the length of the project. Long term projects (greater than three days) should implement driven sign panel warning devices and short term projects should

utilize drums. Additional work zone signing advising motorists of no shoulder should be placed throughout the work zone.

Contractor Access

Contractor access points within the work zone should be controlled. Each ingress and egress point on a project site from an existing traffic lane creates potential conflict points between the contractor and the motorist. These conflict points may create motorist delays and queues, which may contribute to rear-end and side-swipe crashes in the work zone. Ingress and egress points should be minimized or avoided where possible. When they are established they are to be appropriately signed in advance to advise the motorist of the condition and an acceleration/deceleration area should be evaluated. Project designers can enhance this situation by reviewing the ability to provide work zone access that does not conflict with the active traffic lane, staging the work, and providing acceleration and deceleration areas for work vehicles. Contractor use of median crossovers should be restricted and use of exit ramps for these movements required in the contract documents.

Value Engineering Change Proposals

Value engineering reviews are to consider the impacts and costs of the Work Zone Safety and Mobility Policy in the analysis process. All safety and mobility mitigation costs are to be included in the analysis.

Transport Permits for Oversize Vehicles

Route availability is an important necessity for oversize transport vehicles. Designers are to coordinate alternate route availability with region transport permit agents or the transport permit section in the Bureau of Highway-Development, Real Estate Division when placing restrictions on width, height or weight for these vehicles in construction work zones.

Chapter 7 Work Zone Management

7.1Transportation Management Plan Implementation

Work zone management occurs during the construction, maintenance or permitted activity work phase. The transportation management plan (TMP) provisions are to be implemented and engagement of stakeholders is to occur. Work zone safety and mobility are to be monitored, measured and documented using field observation and other pertinent methods.

Project staff is to be actively engaged with local and state law enforcement agencies and emergency service providers to assure open communications concerning mobility and incident management. Crash reports are to be obtained as quickly as they become available. Work zone crashes are to be closely monitored and documented and crash analysis performed to determine if corrective action is to be taken.

A safety and mobility peer team for delivery is to be established to conduct project field reviews of safety and mobility issues and to offer guidance and advice for improving safety and mobility on construction projects. Peer team reviews are required when the mobility thresholds have been exceeded and/or crash rates have increased beyond what was anticipated in the initial analysis for the project. The peer team review will report their findings and recommendations to the Chief Operations Officer and the region engineer for approval. The review will also be used to ensure consistent statewide mobility treatments.

All significant project work zones shall be analyzed for actual volume to capacity ratios, level of service and travel delay times. Field measurements of actual travel times and delays are to be documented. If the analysis shows any of the mobility policy threshold criteria have been exceeded, the delivery engineer is to consider further mitigation action where practical. If delays continue to exceed acceptable threshold levels, a peer team review is required. All data gathered and used in the analysis is to be documented in the project files. This information will be used to review mobility policy conformance and consistency on a region and statewide basis as outlined in Chapter 13.

7.2Internal Traffic Control Plans

An internal traffic control plan (ITCP) is a tool the engineer can use to coordinate and control the flow of construction vehicles, equipment and workers operating in close proximity within the work zone activity area to ensure the safety of the workers.

The development of ITCP's provides for safe traffic control within the work zone and should include the following strategies when the plan is being developed:

- Reduce the need to back up equipment.
- Limit access points to and from work zones.

- Restrict the use of median crossovers on limited access highways.
- Establish pedestrian and worker free areas where possible.
- Establish work zone layouts commensurate with the type of equipment being used.
- Provide signs within the work zone to give guidance to workers, equipment and trucks.
- Design buffer spaces to protect workers from errant vehicles or work zone equipment.
- Provide specific training for workers that is required to be completed prior to entering the work zone. Prohibit workers from entering the work zone who have not completed the training.

The development of the ITCP should be required as part of the contract documents. The ITCP is developed by one or more of the contractor's staff and should be included as part of the project's safety plan.

Throughout the life of the project, the contractor is to assign a competent person to monitor compliance with the ITCP. This person is also required to work with department staff on corrective actions, so that information on changes can be communicated to all personnel on the project site.

Preparation of the ITCP should include the following steps:

- Review contract documents and plans
- Determine the construction sequence and choose the construction stages that require site specific ITCP plans.
- Draw the basic work area layout
- Plot pedestrian and vehicle paths
- Locate utilities, storage and staging areas
- Prepare necessary ITCP notes
- Internal work zone speed limits

Prior to beginning work on the project, the contractor is to develop an ITCP plan for submittal at the pre-construction meeting. The engineer will review and approve the plan before work can begin. The plan should be reviewed and updated on a regular basis at project safety meetings throughout the life of the project. The plan is to be distributed to all personnel working on the project, including inspectors and all sub-contractors.

Critical parts of the ITCP, such as ingress and egress points, are required to be discussed with, and approved by the engineer. A plan for communicating the provisions of the ITCP and the overall safety plan to each worker should also be discussed at the pre-construction meeting.

During construction, the safety officer or designated person for each work shift is responsible to monitor worker activities with respect to the ITCP and take the necessary actions to bring non compliant behavior into compliance with the plan. Examples of such

activities may include workers out of position, working in pedestrian free zones or truck drivers operating at speeds above the designated site speed limit.

Truck drivers should be briefed on how to access the project site, the path to follow while traveling within the site, where to stop for staging and how a spotter will instruct them when working near other equipment. They should also be briefed on procedures for leaving the project area and re-entering the traffic stream.

Chapter 8 Work Zone Safety

Effective work zone traffic control strategy encompasses the safety of all users and is not limited to providing safety measures for the motorist only. There is an increased degree of safety required for workers, traffic regulators, motorists, pedestrians and bicyclists in the work zone.

Work zones must be planned and designed to conduct work operations, and must consider design techniques that address safety impacts to the extent possible.

8.1 Work Zone Considerations

Work Zone Hazards
Each individual work zone must be assessed for hazards. The following is a partial list of examples of conflict points for drivers, workers and traffic regulators that designers need to be aware of while developing the temporary traffic control plan (TTCP):

- Pavement markings
- Clear zone/ safety issues
- Night work visibility issues
- Confusing or conflicting signs, markings and features
- Unstable traffic flow
- Roadway geometrics
- Unexpected queues
- Congestion related crashes
- Roadway configuration, merging tapers and drop lanes
- Vertical hazards, drop offs
- Emergency vehicle access
- Disabled vehicle refuges
- Barrier wall and attenuation
- Lane widths
- Work zone crashes and crash patterns

Designers must also consider the following conditions for workers and traffic regulators when developing a work zone TTCP:

- Work zone protection
- Impaired, distracted or inattentive drivers
- Errant vehicles
- Narrow work zones
- Equipment and materials storage
- Lack of protection behind traffic regulators from approaching traffic
- Escape routes for workers
- Exposure to moving equipment

- Aggressive drivers
- Speeding drivers
- Vehicle crashes and crash patterns
- Work zone access and egress

Workers

While most workers injured or killed by motorists are in an open lane of traffic when struck, TTCP's need to consider worker exposure. Drivers experiencing long delays become impatient and can act unpredictably. Driver conditions include those impaired from alcohol consumption or from legal or illegal drugs. They may also be sleep deprived, aggressive or inattentive. Consider the risk to workers when developing traffic control plans.

Positive Protection

Other than closing the road and detouring traffic, traffic barriers provide the most effective separation between motorists and workers. Consider a strategy that offers the highest level of protection for workers. For mobility applications on a freeway project, barrier wall may be the preferred type of separation, because posted work zone speeds and operating speeds may be established at a higher level, without reduction of speeds for workers present.

While excessive use of barrier could contribute to crashes, crash types should be reviewed. Where barrier wall is used to separate opposing traffic flows, traffic crashes where the barrier wall is struck can occur on a project, but most of these barrier wall hits are shown to be property damage related crashes. On the same project without the wall, many of those incidents would likely have been head on crashes. Design considerations should take into account the application of the barrier wall to reduce exposure to serious crash types.

When using barrier wall, the designer should also take into account the position of the workers located behind the wall. Unless the wall is pinned to the pavement or has a minimal deflection, consideration should be given to improving or creating a lateral buffer space on horizontal curves, where barrier wall has a potential for a higher deflection when struck by an errant vehicle.

Barrier protected work zones should be considered on a project by project basis and not just for long term stationary projects.

Traffic Regulators and Spotters

Although traffic regulators are also workers, their function in the work zone is uniquely different and must be treated as a separate group. Traffic regulator safety is a high priority because they must perform their duties in potentially hazardous situations.

Traffic regulators should not be included in the development of traffic control strategies until all other reasonable means of traffic control have been considered, such as temporary traffic signals, detour routes and alternative traffic control plans.

Traffic regulators are typically used to stop and direct traffic for work activities such as one lane alternating traffic control, intersection control, road closures and short duration spot locations on low speed roads where ingress and egress of construction materials and equipment is necessary.

Using traffic regulators solely to instruct motorists to proceed slowly is ineffective and is an unacceptable practice.

When providing traffic regulators for night construction, the traffic regulator station must be adequately illuminated.

Traffic regulators need escape routes in case of an errant vehicle or other hazards. The traffic regulator's location, escape route, protection and other safety related issue all need to be incorporated into the TTCP for the traffic regulator operation.

Law enforcement may be used for some traffic regulator operations. Law enforcement personnel are the only personnel allowed to regulate traffic from the center of an intersection, and are not required to cover or remove existing traffic control devices, such as signs or traffic signals to perform their work.

If traffic regulators are used at an intersection, a traffic regulator is required for each approach leg. When multiple lanes are present at the intersection, close the lanes so there is only one lane of traffic approaching the traffic regulator. When using traffic regulators at signalized intersections, the signal must be turned off and bagged, placed on flash mode, or operated manually to control traffic. When the signal is operated manually, it will be operated by trained department staff and the operation is only intended for use for periods of time not to exceed 5 minutes.

A spotter is used solely to alert workers. The spotter can be used to watch traffic and alert workers of the approach of an errant vehicle. A spotter does not use a traffic regulator paddle, but instead uses a warning sounding device. When a warning sounding device is used, the sound should be different than using a conventional horn that could be mistaken for a typical vehicle. The device used should be identified to all workers on the site so that when it is used, the workers will understand the sound and potential actions to take.

Use spotters only when the risks of workers exceed those of the spotter. Intended spotter locations are to be shown on the TTCP.

Road Users

Road users assume they have the full use of the roadway, unless directed otherwise. The message conveyed to the user through signing, markings, and devices must be consistent and credible.

> **Drivers –** Drivers and their passengers account for more than 90% of work zone fatalities. It is important to provide a TTCP that effectively guides and protects

drivers while traveling through the work zone. Effective planning and design of work zones begins with the driver, and work zone design must be initiated from the driver's perspective. Design expectations for the driver are that they can easily understand the traffic control and have adequate time to react or make rational decisions.

Work zone temporary channelization and alignment must be designed to accepted current roadway geometric design policies. Temporary channelization and alignment are not to be based on a design that may fit a given location without regard to safe design or predicated on a reduced speed that drivers may not follow.

Perceived, insufficient, conflicting or too much information conveyed by signing can potentially confuse the motorist and contribute to erratic driving behavior.

Pedestrians – In work zones, adequate facilities are required to be provided to allow pedestrians to travel through or around the work zone. This may include providing for temporary pathways. When existing pedestrian facilities are disrupted, closed or relocated in a work zone, the temporary facilities are required to meet the requirements for Americans with Disabilities Act (ADA) compliance, and be the same design as the existing facility.

Bicyclists – Bicyclists are allowed on most highways and streets. Within work zones on higher speed facilities, bicyclists will not be able to match the speed of motorized vehicles and a different route or detour should be considered to improve safety and to reduce vehicular delays. When this is not possible, bicyclists can be instructed to dismount their bikes and walk their bikes through the work zone on the route provided for the pedestrians.

If it is feasible to maintain bike access through the work area with shoulder use, at least the minimum shoulder width to accommodate bicycles should be designed into the plans. Work zones where there are no alternate paths available must require the existing paths to be closed and a detour route provided or other applicable mitigation measure taken.

Motorcyclists – The riding surface is important for the safety of motorcycle riders. Whenever possible, construction operations should be avoided that place motorcycles on grooved pavement, milled surfaces, pavement lane edge drops from milled surfaces, rumble strips and unpaved surfaces. If these conditions cannot be avoided, the TTCP must include adequate warning signs for these conditions to alert the motorcycle rider. If the project is altered during the construction process, these conditions must be approved by the engineer before they occur, and the contractor must provide adequate warning signs for these conditions. Consideration should also be made for ingress/egress points, where designs should include the capability of a motorcyclist accessing the roadway perpendicular to differentials in pavement elevations.

Oversized Vehicles – If the TTCP design for the proposed work zone will not allow vehicles that exceed the legal width, height or weight limits for vehicles, provide adequate warning signs, and notify the region/TSC transport permit agent of the work zone restriction. On some projects, it may be necessary to designate a detour route for oversized vehicles.

8.2 Work Zone Enforcement

Work zone enforcement can be an effective tool to alter or improve motorist behavior when entering or traveling through a work zone. These alterations or improvements are done in two ways.

One is by placing an enforcement person within the work zone to be visible, but typically not provide enforcement. This application has an effect on a very high percentage of motorists, since they are not actively pursuing enforcement, but are available to do so at any time.

The other application is active enforcement. In many work zones, active enforcement is typically used in the area immediate to the workers, where lower work zone speeds are in affect. This type of enforcement helps to enhance work zone rules and regulations regarding motorist behavior.

Other types of work zone enforcement support actually provide support as work zone traffic control. Typical applications of work zone traffic control include working intersection control where an active traffic signal is present or traffic stoppages on roadways. This type of traffic control should be limited to short periods of time. For longer work durations, it is desirable to provide other types of traffic control using applications typical to work zones.

Work zone enforcement should be determined prior to the project start up, then as needed throughout the project. TSC personnel should meet with all applicable enforcement communities in their areas, and make available to them a list of projects for the season, and ask for the enforcement communities to volunteer their services, both in an active role as part of their daily patrol, and as part of the overtime assistance monies provided through the department.

8.3 Review and Analysis of Work Zone Crashes

Work zone crashes are divided into two categories, crashes that are attributable to the presence of the work zone and crashes that would occur even if the work zone was not in place. Work zones also contribute to changes in crash types. Many crash types associated with day to day driving may be greatly reduced with the introduction of a work zone. Other crash types actually increase with a work zone present while other crash type rates remain constant. These impacts must be considered and minimized where possible when designing the work zone temporary traffic control plan.

Most work zone crashes are congestion related. Typical work zone crashes due to this condition are rear end crashes as a result of traffic queues. Other contributions to work zone crashes are due to lane width restrictions and location of traffic lanes in close proximity to fixed objects. During TTCP design, the advance warning signing should take into account traffic backups that will occur during the project. The TTCP should include the proper traffic control devices to warn the motorist of hazards that they not have been exposed to previously.

In order to review the potential changes in crashes due to the introduction of a work zone, as well as determine if adopting certain work zone strategies might reduce work zone crashes, it is important to review the existing crash patterns of the roadway prior to construction, and review a project with a TTCP with similar characteristics to the one being designed. Work zone crash data for the control section(s) of the proposed project should be reviewed to determine if there is an existing pattern that will impact the job. Crash data can be obtained by accessing the Transportation Management System/Safety module discussed further in Chapter 12.

The safety goal for placing a work zone onto a road system should be to minimize the work zone crash rate as much as possible. Pilot studies of project crash rates have suggested that it is possible to reduce the overall crash rates on roads under construction to approximately half of the roadway's pre-construction crash rate by implementing crash reducing maintaining traffic strategies.

In order to perform an analysis for design, the following steps must be performed:

1. Identify a completed project work zone with similar project length, similar scope of work, and geometric cross sections to the project that is being designed
2. Review the crash data from the completed project to determine potential corrective maintenance of traffic strategies, based on the crashes or crash patterns and identify those potential best practices for reducing the crashes caused by the construction work zone.
3. Review the crash data from the area where the new design is being developed and identify potential best practices for reducing those crashes that occurred prior to construction.
4. Determine if a best practice is available for the new project design based on the outcome of the review in step 2.
5. Combine the results of Steps #3 & #4 and determine if there are crash patterns that could be resolved through the design of the temporary traffic control to minimize the crashes that occurred prior to construction and minimize the potential for crashes during the construction.

Designers are encouraged to investigate mitigation techniques employed by other TSCs that may have had similar projects and to research the websites discussed in chapter 16s, in this manual.

The following pages describe in more detail the steps to be followed when looking at information for the development of temporary traffic control plans.

Previous Project Design
Identify a project already constructed that has similar location, size, traffic type and traffic control being designed into the new project.

- Determine the mile points of the project, including the advance signing sequence, then add additional mileage to capture potential backup crashes.
- Retrieve crash data related to the parent project.
- Determine what crashes occurred and where they occurred due to the work zone by review of individual UD-10's (police crash reports).
    a. Are there correctible patterns or locations?
- Determine what crashes occurred in the work zone not related to work zone activities.
    a. Are there correctible patterns or locations?
- Determine if a best practice or policy exists that was developed for other projects that would apply to the new project and apply those practices into the third and fourth bullet above.

New Project Design
For designing the new project, use the data retrieved above to design corrections into the new project design.

- Determine the mile points of the project, including the advance signing sequence, then add additional mileage to capture potential existing crashes that could influence work zone design.
- Retrieve crash data for the approximate time period of the project to determine what crash patterns exist on your project site.
    a. Determine if existing crash patterns can be reduced through design of traffic control plans.
- Import crash data from the previous project design to determine where work zone crashes will occur.
    b. If no pattern exists, typical crash patterns can be expected to develop at interchanges, ingress/ egress points, contractor access points and lane closure or shift points.
- Are there established best practices in use by the Department that could be employed to reduce expected crash patterns?

During Project Construction
During the project, the delivery engineer is to assign a person to monitor work zones crashes. Monitoring work zone crashes during the project and reviewing potential corrective actions may help to reduce or eliminate additional crashes in the work zone. Crash reviews may also indicate no corrective action is needed.

This person should also establish a relationship with relevant law enforcement agencies that patrol the project and request notification of crashes and to collect UD-10 information as soon as possible when it becomes available.

When appropriate, work with towing companies to provide additional information, or work within the construction contract to provide towing services on the project to keep roadways clear.

The assigned person should work with emergency service incident responders to develop incident responder plans. Incident responders are responsible for the protection of the incident area, and the need to move traffic is not their highest priority. Incident responder plans should contain provisions to initiate site protection with the goal of reopening the lanes or roadway as quickly as possible.

On site inspections and comments by others not specifically assigned to the project should be encouraged. People who are not familiar with the project may see things that the project staff has not observed.

When project issues occur that cannot be corrected at the project level, request assistance from the safety and mobility peer team described in Chapter 2, Section 2.7.

Chapter 9 Work Zone Devices and Traffic Control

All traffic control devices used in work zones are required to meet the requirements of Part 6 of the Michigan Manual of Uniform Traffic Devices (MMUTCD). The MMUTCD contains references to other manuals to be followed by both the designer of the TTCP and the contractors who implement the plan.

Federal regulations also require that all roadside appurtenances such as portable sign stands, barricades, barrier terminals, crash cushions and other work zone hardware be compliant with the National Highway Research Program 350 crash test requirements.

In addition to usage requirements contained in the MMUTCD, the following usage criteria should also be followed when determining traffic control device usage:

Cones – Cones are prohibited for use at night.

Plastic Drums – Plastic drums are required for use when working at night, except where lane width restrictions or other TTCP design issues may occur.

Tall Channelizing Devices – Tall channelizing devices are used where a plastic drum cannot be used due to lane width restrictions or other TTCP design issues exist. They are required for use in all capital preventive maintenance projects. They may be used in both taper and tangent sections for daytime applications and standard spacing requirements apply. For night work, they may only be used in tangent sections. Because of their narrow footprint, maximum spacing in tangent sections for night work is 50 feet, regardless of the posted speed limit.

Tubular Markers – Tubular markers are not a recommended device, unless they are being used to separate traffic or work operations on low-volume, low speed roadways. They also have been successfully used in work zones where more permanent delineation may be required during winter shutdown. They are required to have a minimum height of 36 inches, and have a minimum diameter of 3 inches. Reflective sheeting requirements shall be the same as required for a plastic drum. Use of tubular markers is allowed after all other channelizing devices have been considered for use and ruled out.

Vertical panels – Not allowed for use except as noted on the plans.

Directional Indicator Barricades – Not allowed for use.

Barricades – Barricades are used to control traffic by closing, restricting or delineating all or a portion of a roadway. There are four barricade types, Type I, II, III and directional. Only Type III barricades are allowed for use, all others are prohibited.

Longitudinal Channelizing Devices – Longitudinal channelizing devices are barrier systems such as water filled barrier. They are not intended as a replacement for concrete barriers, but to provide continuous delineation through a work zone. A typical application of this device would be to define a travel path for pedestrians to meet Americans with Disabilities Act (ADA) requirements.

Barriers – Barriers are used to separate opposing traffic movements and to separate road users from the work zone. Types of barrier protection used in construction work zones include concrete barriers, movable barriers, steel barriers and water filled barriers.

Barriers can be one of the most effective safety measures used in a work zone, because of the effective use of separating the workers and work area from traffic. The following is a listing that includes elements to consider when deciding on the use of barriers:

- Excavations
- Drop offs
- Unprotected features (walls, piers, sign structures, foundations, etc.)
- Working and non working equipment
- Interim unprotected features or objects (non-standard slopes, stockpiles, ditches within the clear zone, etc.)
- Worker exposure within 6 feet of an open traffic lane
- Number of workers
- Proximity to hazards
- Time duration of exposure
- Suitable work area available to workers
- Traffic exposure to work hazards
- Traffic exposure to other traffic

Barriers are normally installed for:

- The separation of opposing traffic for extended periods of time.
- Where drums or cones do not provide adequate guidance for the motorist or for the protection of the worker.
- Multiple lane separations in a long term stationary work zone.
- Where workers are exposed to unusually hazardous traffic conditions.
- Where existing traffic barriers and bridge railings are removed during a construction stage.

The following alternatives to using temporary barrier should be considered due to risks to drivers and workers during placement and removal of the devices:

- Buffer lane closures
- Nightly backfill of excavations
- Temporary tapers
- Temporary detours or crossovers

- Additional or closer spacing of channelizing devices and extra warning signs

The protective requirements of a temporary traffic control situation should have priority in determining the need for temporary traffic barriers and their use should be based on an engineering study. The following factors should be considered before using temporary traffic barriers:

- Speed/volume of traffic
- Vertical/horizontal roadway alignment
- Severity of hazard/excavation/obstacle
- Duration of exposure
- Duration of temporary traffic control zone
- Hazard presented by barrier itself once it is in place
- Hazard presented to workers and traffic during barrier placement

Temporary Concrete Barriers – These barriers are used in long term stationary work zones and to replace existing barrier and bridge railings removed during construction. Lateral deflections cannot exceed 6 feet 6 inches. When any barrier displacement is unacceptable, barriers are required to be anchored to the roadway or bridge deck. The ends of these barriers are not crashworthy and must be located outside of the clear zone or fitted with an impact attenuator.

Movable Barriers – These barriers are specially designed segmental barriers that can be moved laterally as a unit to close or open a traffic lane and should be used if frequent or daily relocation of the barrier wall is required. Adequate storage sites at both ends of the barrier are required for the barrier moving machine. The ends of these barriers are not crashworthy and must be located outside of the clear zone or fitted with an impact attenuator.

Water Filled Barrier – Consideration for using this barrier should be limited to low speed, low volume roadways where an improvement over the use of traffic cones or drums is needed. Water filled barrier is not to be considered as a replacement for concrete barrier. These barriers are not recommended for use due to their large deflection and potential penetration when impacted.

Impact Attenuators – Within the clear zone, the approach ends of temporary concrete barriers are fitted with impact attenuators to reduce the potential for occupant injury during a vehicle collision with the barrier.

Whenever possible, application of attenuators should only occur when the deployed devices cannot be positioned outside the clear zone. The device should be positioned so that it is a minimum of 6 feet 6 inches from the travel path of the motorist. A narrow design impact attenuator is required when that distance cannot be obtained.

Truck Mounted Attenuators – Use of truck mounted attenuators is not a replacement for a standard impact attenuator used to protect the ends of barrier wall.

Fixed Temporary Signing – Fixed temporary signing mounted on conventional sign supports should be used for projects that last more than three days. When preparing the work zone signing plans, review all existing signing locations in advance of and within the work zone for consistency of sign locations. Cover or remove existing signs that can be misinterpreted or be inappropriate during construction.

Portable and Temporary Signing – Portable and temporary signing is generally used in short term and mobile work zone operations where frequent repositioning of the signing is necessary to keep pace with the work along the roadway. These signs are to be mounted on crashworthy sign supports. Portable sign supports are also used where it is not possible to use fixed sign supports.

Delineation – Pavement markings provide motorists with clear guidance through the work zone and are necessary in all long term work zones. Temporary pavement markings can be either paint or preformed tape and should be selected based on the existing pavement surface. Remove existing pavement markings that are confusing or contradictory on projects that will remain in place for three days or more. Other types of delineation devices are delineators, concrete barrier reflectors and lateral clearance markers and should be included in the TTCP.

Consider types of pavement marking for their potential for scarring during removal. Scarring can provide a permanent shadow of a line that may be followed by a motorist. Temporary markings should be designed and placed to overpower the scarring that may create these shadows.

Illumination – Illumination is justified if construction activities take place on the roadway at night. Illumination might also be justified for long term construction projects at the following locations:

- Road Closures with detours
- Road closures with diversions
- Median crossovers on freeways
- Complex or unexpected alignment or channelization
- Haul road crossings if operating at night
- Temporary traffic signals
- Disruption of an existing illumination system

When traffic regulators are necessary for nighttime construction activities, supplemental lighting of the traffic regulators stations by using portable light plants or other approved methods is required.

Portable Changeable Message Signs – Portable changeable message signs can be programmed with specific messages which can be modified as needed and are supplemental to other warning signs. The maximum number of message panels allowed at one location is two. If additional information is necessary, an additional sign should be

used at a separate location. The following are some typical situations where portable changeable message signs are used:

- Where traffic speed is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions, such as ice and snow, are present
- Where there are extreme changes in alignment or surface conditions
- Where advance notice of ramp, lane or roadway closures is necessary
- When crash or incident management teams are used.

On high impact projects, on projects where a substantial number of portable changeable message signs will be in use or where portable changeable message sign usage will require placement of the device a considerable distance from the work area, the portable changeable message sign design should include requirements for remote access protocols, so that message modifications may be made without having to visit the actual site.

Temporary Portable Traffic Signals – Temporary signals are typically used in work zones to control traffic where one lane is closed and alternating traffic movements are necessary.

- **Temporary Signal System** – A permanent signal system typically modified in a temporary configuration is recommended where there is adequate power available and the temporary signal will be in place for 30 days or more.
- **Portable Traffic Signal System** – A trailer mounted traffic signal system used in work zones to control traffic. These systems may be used when the work zone does not have adequate power available, or the temporary signal will be in place for 30 days or less.

Portable Highway Advisory Radio – Highway advisory radio is a system that provides traffic and travel related information via AM radio. The system may be a permanently located transmitter or a portable trailer mounted system that can be moved from location to location.

Automated Flagger Assistance Device – The automated flagger assistance device is a traffic regulator machine that is operated remotely by a traffic regulator located off the roadway and away from traffic. The device is a safety enhancement for projects that use alternating traffic control by physically placing the human traffic regulator off the roadway while maintaining control of the traffic movements approaching the work zone. Automated flagger assistance devices should only be considered for use where escape paths for traffic regulators cannot be established.

Screening – Screening is used to block the motorist's view of construction activities adjacent to the roadway that may be a distraction to the motorist. Screening should be placed behind barrier wall where it cannot be struck by an errant motorist. Screening is required to be anchored or braced to resist overturning by wind.

Glare Screening – Glare screening is used on concrete barriers separating opposing traffic to reduce headlight glare from oncoming traffic. This screening also reduces the potential for motorist confusion by shielding the headlights of other vehicles on adjacent roadways or construction equipment. Glare screening should be used on all projects where temporary concrete barrier is used to separate opposing lanes of traffic, with the exception of moveable barrier wall, where the equipment used to move the wall conflicts with any device installed on the top of the wall.

Transverse Rumble Strips - Transverse rumble strips are used to alert the driver to unusual vehicular traffic conditions which could include unexpected changes in alignment and to conditions requiring a stop.

The color of a transverse rumble strip used within a travel lane is to be the color of the pavement or else white.

Transverse rumble strips should be placed on all freeway projects that remain in place for 3 days or more, unless there are considerations for placement where the noise generated by the rumble strips may cause customer complaints. Transverse rumble strips should also be installed in advance of all temporary traffic signal locations that are in place for three days or more.

Longitudinal Rumble Strips – Longitudinal rumble strips could cause driver behaviors that may not be desirable when traffic is shifted to accommodate work. For work where traffic is being shifted onto the shoulder that places the motor vehicle wheel track within 12 inches of the rumble strip, the rumble strips should be either removed or filled.

In transition areas where traffic is being shifted across the rumble strip, but driving in the rumble strip will not occur in the tangent section, signing shall be placed advising the motorist of the rumble strip crossing.

In the tangent areas where the rumble strip will not be removed or filled, signing should be installed at the beginning of the project and after every interchange to advise the motoring public of the rumble strips.

Chapter 10 Intelligent Transportation Systems and Technology

Safety and mobility within work zones and along alternate routes for traffic that divert around work zones can be greatly enhanced through the application of existing and emerging technologies. These technologies are typically referred to as Intelligent Transportation Systems (ITS). ITS solutions can reduce the delay through and around a work zone by:

- Providing traffic monitoring and management through, approaching and around a work zone. This information can be used to monitor, and adjust as necessary, a project's temporary traffic control plan.
- Collecting traffic data for near-real-time distribution to partner agencies and the media. In addition, project staff can monitor and adjust a project's temporary traffic control plan as necessary with this information.
- Collecting traffic data for historical analysis, to provide an evaluation of the effectiveness of a project's traffic operations plan and to forecast traffic conditions for similar future projects.
- Providing traveler information to allow motorists to modify their planned trip to minimize delays caused by a work zone.
- Providing for the safety of motorists and workers alike, by providing advanced notice of work zone and traffic conditions.

When designing or deploying a work-zone related ITS solution, region/TSC development and delivery personnel should work with their region's ITS representative. A work zone or project delivery program would need a complete assessment and evaluation before determining what measure or combination of ITS measures would work best, and before deploying any particular ITS measure. Not all ITS solutions are applicable for every situation.

When planning for the deployment of an ITS solution, sufficient time must be provided for the design, set up, calibration, and testing and evaluation of the system. The proper selection of an ITS solution should be accomplished and budgeted for during the planning and scoping phases of a project; bid items for the selected ITS solution(s) must be included in the project construction documents.

Following are potential ITS strategies that can be used to help manage work zone traffic.

Permanent systems (cameras, detectors, signs)
A typical ITS/traffic management system in Michigan includes the use of permanent dynamic message signs, closed-circuit TV cameras, permanent vehicle detector stations, and an operations center that is staffed at a minimum during the peak traffic periods. Each of these system components should be leveraged by construction staff to assist in work zone traffic management.

Real-Time Work Zone Information Systems
Real-time work zone information systems provide real-time travel time information to motorists, and encourage motorists to use alternate routes during periods of long delays through the work zone area. An information system can be set up to measure travel time through a work zone, or along alternate routes.

With a real-time work zone information system, a central computer system will collect speed and traffic volume data from portable roadside sensors, calculate an estimated travel time along select travel links and posted the travel information on either variable number – static message signs or dynamic message signs.

A real-time work zone information system needs to be periodically checked and calibrated throughout the life of the project by measuring travel times, and comparing these values to real-time and historical travel time displays.

Temporary portable cameras
Temporary portable cameras can be placed at key areas within the work zone (such as at the point of a lane drop/merge) in order to provide a visual representation of current traffic conditions in and around a work zone. Construction project staff can evaluate current traffic conditions and consider options for changes or additional traffic control measures based on the real-time traffic conditions shown.

Images from the temporary portable cameras can typically be viewed using a web-based application. In areas with a permanent traffic management system, the camera images can usually be included and monitored with images from the permanent camera stations.

Images from the temporary portable cameras can also assist with incident management and the quick clearance of incidents in work zones by providing accurate, real-time images to dispatch centers and emergency first responders.

Variable speed limits
Static speed limits may not reflect current conditions, and could lead to low speed limit compliance, and high variance in distribution of vehicle speeds. Variable speed limit systems use sensors to monitor prevailing traffic and/or weather conditions, posting appropriate enforceable speed limits on dynamic message signs. The use of variable speed limits can improve speed limit compliance and the safety of traffic flow by promoting and facilitating uniform traffic flow.

Queue Detection
A queue detection system can determine where queues start approaching a work zone using a series of traffic detectors, portable dynamic message signs, permanent traffic detector stations and dynamic message signs (if available) for communication of that information to drivers in advance of the work zone.

Dynamic lane merge systems (Early / late merge)
These systems actively monitor and direct traffic streams to merge due to lane closures in order to promote uniform traffic flow and traffic speeds while approaching a work zone. Uniform traffic flow and traffic speeds can help to reduce traffic turbulence and aggressive driving that may have an adverse impact on traffic crash rates and mobility.

Dynamic lane merge systems use roadside detector systems and portable dynamic message signs to monitor traffic flow. As queue increases are detected near the approach to a lane closure, the system regulates merging traffic by providing information and direction to motorists, requiring either an early or late merge into a single lane.

Dynamic lane merge systems have been shown to help reduce confusion of lane use issues and correct merge points, help reduce aggressive driver behavior approaching a lane closure, ensure that near equal usage of the contiguous and closing lanes are maintained and reduce the overall queue lengths experienced without changing the total amount of traffic going through a work zone.

Highway Advisory Radio
Highway advisory radio systems use a combination of roadside traffic monitoring devices, radio equipment and signs that can broadcast real-time traffic information and construction update messages, typically over an AM radio frequency. When properly deployed, monitored and maintained, highway advisory radio systems can provide motorists with useful, timely information such as current traffic conditions, delays approaching and through a work zone, a status of the project's schedule (including planned lane and ramp closures) and information on any incidents in the area of the project that may have an adverse impact on traffic in the area.

In order to be effective, messages provided on a highway advisory radio system need to be accurate, updated and timely.

Close partnerships with local media outlets could also provide the same benefits as a highway advisory radio system.

Website – traffic data / information / conditions
Large-scale projects can typically include a project-specific website which may include a graphical depiction of traffic conditions approaching and traveling through a work zone. This website can also include detailed project information, including project schedule updates and status of lane and shoulder closures.

One option to establishing a project-specific website could involve leveraging existing resources that can provide traffic and construction information, such as the Department's own "Drive" website, and commercial resources such as Traffic.com and the websites of news broadcast agencies in the local area. Contractors may include a graphical web-based interface that presents traffic data and conditions that their system is monitoring.

Automated fax/e-mail updates
Using an assembled list of e-mail addresses and fax numbers, an automated notification system for stakeholders can be developed. Notices can be sent out when significant traffic events occur, such as construction stage or phase changes, crashes in work zones, traffic congestion approaching the work zone and other information.

Portable traffic detectors/sensors
Portable traffic detectors can be deployed to measure traffic volumes, speeds and classifications. This information can be used as an integral portion of a larger deployed system including real time information systems, dynamic lane merge systems, queue detection systems and permanent system.

Portable detectors and sensors can be used for stand alone applications such as project websites and to collect real-time traffic data for distribution, and historical traffic data for work zone performance analysis.

Ramp metering
A ramp metering system includes traffic signals on freeway entrance ramps that help regulate traffic flow and promote uniform flow of traffic into a freeway traffic stream. This traffic flow regulation can minimize disruptions in traffic flow and traffic turbulence by regulating the gaps between vehicles that enter a freeway traffic stream.

An effective ramp metering program would likely include more than one ramp or interchange location, since benefits would be best realized by taking a systems approach. Care also must be taken to ensure proper geometry is provided on the entrance ramps, as this is critical for such a signal system to function properly. This could end up being cost prohibitive for temporary use in construction projects. In addition, significant law enforcement support is needed with any ramp metering system in order to maximize its effectiveness.

Temporary Traffic Management Centers
If a work zone is not located in an area monitored by a permanent traffic management or traffic operations center, consideration can be given to establish a temporary traffic management center. A temporary traffic management center can be provided to monitor individual or a combination of ITS and traffic management systems. Consideration must be given to staffing, housing facility and connectivity with the work zone and project influence area.

Chapter 11 Mobility Analysis Tools

Understanding the anticipated type, severity and extent of work zone impacts aids the development of effective transportation management plans. Analysis will necessitate the use of analytical tools depending on the degree of analysis required. Some tools were designed for work zone related analysis while other traffic analysis tools that were not specifically designed for work zones may also be useful for analyzing work zone situations. This chapter discusses various tools available to perform the analyses required to develop and implement transportation management plans.

Highway Capacity Manual (HCM)

This guidance document contains concepts, guidelines and computational procedures for computing the capacity and level of service on various facility types. The Highway Capacity Manual can be used for both planning and operational analyses. Planning analysis gives measures of effectiveness such as time delay, average travel speed, level of service and volume to capacity ratios. Operational analysis allows for diagnosing, testing and designing mitigation measures.

Traffic Tools	Planning	Operational
Facility	HCM - Chapter 29 (corridor analysis)	HCM Ch. 21 & 23-25 (freeways, ramps, weaves) Ch. 18 & Synchro (Signals)
Network	Regional Planning Models (e.g., SEMCOG) HCM Ch.30 (area wide analysis)	Over-Capacity Situations: Simulation Meso & Micro HCM Ch. 22 (freeway facilities)

Travel Demand Models

Using the four step model process and TransCAD as the software, travel demand models are used to identify existing and future highway capacity deficiencies and analyze potential transportation improvements. Travel demand modeling refers to the development of a series of mathematical relationships, specifically designed to simulate existing and forecasted travel patterns. TransCAD is the software tool used to implement the model.

Travel demand models have been developed for all large urban areas in Michigan. A Statewide model has also been developed to evaluate alternatives outside of urban area boundaries. Travel models replicate existing traffic, the effects of any impedance to that

traffic, plus where and when future travel congestion will occur. They can also estimate the impact of congestion, either in terms of changes in the level of service or the amount of delay saved from future transportation improvements. This allows a comparison of the benefits between various transportation projects.

In complex situations or for high impact projects these models should be used to evaluate the diversion of average daily traffic from work zones due to lane closures or other impedances as well as to identify routes that will be impacted by work zone lane closures.

Construction, Congestion, Cost (CO3)
This is a software tool that estimates the magnitude and impacts of traffic congestion, including cost impact on road users that can be expected during a construction project. CO3 measures congestion variables such as delay, diverted vehicles, and backup. In addition, a user can estimate and document project costs for alternative ways of maintaining traffic and the changes in construction they require. As all regions have this software available to them, this program should be used to estimate travel time delay in work zones for various work zone alternatives.

Quickzone
A traffic impact analysis tool that can be used to estimate work zone delays, QuickZone provides results in an easily readable spreadsheet form. The software compares the traffic impacts for work zone mitigation strategies and estimates the costs, traffic delays, and potential backups associated with them. Costs and delays can be estimated for both an average day of work and for the entire life cycle of construction. Key measures include: length of total mainline queue, total mainline delay in vehicle hours, total passenger car costs, total travel time in minutes, and detour delay costs.

QUEWZ-92
A microcomputer analysis tool that can be used to plan and schedule use in freeway work zone lane closures. It analyzes traffic conditions on a freeway segment with and without a lane closure in place and provides estimates of the additional road user costs and of the queuing resulting from a work zone lane closure. The road user costs calculated include travel time and vehicle operating costs.

Construction Analysis for Pavement Rehabilitation Strategies
A software tool that supports integrated analysis of project alternatives for different pavement design, construction logistics and traffic operations options. The program considers scenarios for such variables as rehabilitation strategy, construction window (i.e., nighttime, weekend, or continuous closures), number of lanes to be closed, material selection, pavement base type and the contractor's logistics including access to the site and production rates. Construction Analysis for Pavement Rehabilitation Strategies software output can also be integrated with traffic simulation tools to estimate road user delay costs arising from construction.

Dynasmart-P
A dynamic traffic assignment analysis tool that can be used for regional work zone management, this program combines dynamic network assignment models, used primarily with demand forecasting procedures for planning applications, and traffic simulation models, used mainly for traffic operations studies. Potential applications include assessing the impacts of alternate traffic operations and control strategies, evaluating strategies for work zone, incident, and special event management, and assessing the impacts of intelligent transportation system technologies on the transportation network. In addition, one can evaluate congestion-pricing schemes for toll roads and produce traffic operations data for air quality analyses.

SYNCHRO and SIM Traffic
These programs are utilized by the Bureau of Highway-Delivery, Traffic and Safety Division for signal timing and geometric design evaluations. Many validated models exist and could be utilized for work zone alternative evaluation. Outputs include travel times, levels of service and other measures of effectiveness.

- SYNCHRO is a macroscopic capacity analysis and optimization model which performs a straight-forward analytical capacity analysis that allows the user to get a measure of delays, queues, etc. based on equations. Synchro will also optimize signals in a network. Synchro uses volume to capacity ratios, rather than delay, to measure the true capacity of an intersection.

- SimTraffic is a microscopic simulation model that fully simulates signals, unsignalized intersections (including roundabouts) and the interaction that occurs within. SimTraffic uses the inputs for Synchro models, making it quicker to simulate then with other simulation programs.

VISSIM
A microscopic, time step and behavior based simulation model developed to analyze roadways and transit operations. It accurately simulates urban and highway traffic including pedestrians, cyclists and motorized vehicles. VISSIM can model integrated roadway networks found in a typical corridor as well as various modes consisting of general-purpose traffic, buses, high occupancy vehicle lanes, high occupancy toll lanes, rail, trucks, pedestrians, and bicyclists. Changeable message signs, ramp metering, incident diversion, transit signal priority, lane control signals, and dynamic lane control signs can also be modeled in the program.

Note: This program is quite data intensive and requires special expertise. It should be limited to those situations in highly urbanized areas where impacted roadways are typically at capacity.

Paramics
This suite of microscopic simulation modules provides a platform for modeling a complete range of real world traffic and transportation problems. The modeling tool provides three fundamental operations - model build, traffic simulation and statistical

output. The analyzer tool is a data analysis tool used for custom analysis and reporting of model statistics. It also provides user definable Highway Capacity Manual style level of service and measures of effectiveness information.

Note: This program is quite data intensive and requires special expertise. It should be limited to those situations in highly urbanized areas where impacted roadways are typically at capacity.

Chapter 12 Data Management

The provision that pertains to use of work zone data is provided in Section 630.1008(c) of the Work Zone Safety and Mobility Rule. This provision requires agencies to use work zone data at both the project and process-levels to manage and improve work zone safety and mobility.

- At the project-level, requires agencies to use field observations, available work zone crash data, and operational information to manage the work zone impacts of individual projects while projects are underway in the field.
- At the process-level, requires agencies to analyze work zone crash and operational data from multiple projects to improve agency processes and procedures, and in-turn continually pursue the improvement of overall work zone safety and mobility.
- Recommends that agencies maintain elements of the data and information resources that are necessary to support the use of work zone data for the above two activities.

Work zone data are necessary to make an informed assessment of the effectiveness of efforts to manage work zones safety and mobility impacts. Work zone field data also enable agencies to assess how well planning and design estimates of anticipated impacts match what actually happens in the field. Work zone data support performance assessments at both the project and program-levels. Available data and information provide the basis for assessing performance and taking appropriate actions to improve performance on individual projects as well as overall processes and procedures.

12.1 Scoping, Planning and Design Phase

Traffic Information

Most traffic information utilized during scoping, planning and design phases can be found through accessing the TMIS application. This application is found on the connect MDOT website. Under the MDOT drop down box, click on the Applications tab. Activate the application Traffic Monitoring Information System under the Applications & Systems area within the Applications window. If available, traffic data elements include:

- Traffic estimates (AADT, DHV, etc.)
    - Annual Average Daily Traffic (AADT)
    - Commercial Average Daily Traffic (CAADT)
    - Directional Factor
    - Design Hour Volume Percent
- Hourly traffic volumes
- Hourly vehicle classification volumes

- Permanent Traffic Recorder (PTR)
    - Hourly
    - Daily
    - Monthly and annual reports
    - Vehicle classification (limited locations)
    - Average speeds (limited locations)
- Operational Type Traffic Studies
    - Travel time (very limited)
    - Turning movements

If traffic data is not available through TMIS, the BTP, Asset Management Division, Data Collection Section can collect the traffic data necessary to support the analysis. To request a traffic study from the Data Collection Section, complete MDOT form 1776 identifying the data requirements and submit according to the instructions given on the form. The form 1776 can be accessed through the connect MDOT website under MDOT forms. It is important to define the traffic data needs as early into the process as possible to provide time to collect the data.

For the purpose of capturing the location of all work zone studies, each project manager is to ensure that a work zone safety and mobility study record is identified within the TMIS. The study record can be created by the region or by contacting the BTP, Asset Management Division, Data Collection Section at (517) 373-2249. This TMIS record is not meant to store the analysis or supporting data, but a record that a work zone safety and mobility study was conducted. This TMIS record must contain the following information:

- Type of Study (Drop down menu select Work Zone Study)
- Study Number (See Help function for help)
- MDOT Region
- County Name
- Control Section (CS)
- Physical Reference (PR) #
- Requester

Optional information about the study should be recorded in the "Elements Of Study" field. This would include noteworthy information such as:

- The location in ProjectWise where supporting data and analysis is stored.
- Detail contact information (e-mail address and or phone number)

All questions regarding the TMIS can be addressed to the Data Collection Section in the Bureau of Transportation Planning, Asset Management Division.

Crash Data

Crash data is available from the Crash Data Base (Data Mart) using the Transportation Management System (TMS). The TMS application software to access the data can be

obtained by contacting the Bureau of Highway Operations, Traffic and Safety Division at (517) 335-1187. On average, there is a twenty two (22) day turn-around from the completion of the UD10 (police officer's crash report) to the posting of the data in the DataMart. Crash information utilized during project development phases can be analyzed by using the TMS, Safety module.

12.2 Delivery

Within the planning and design process, data requirements must be identified which will provide the ability to conduct the necessary project level analysis of work zone safety and mobility. Project staff must identify the supporting data, resources (internal or external) and tools necessary to coordinate and conduct the data collection to meet the project level analysis requirements.

Work Zone Mobility
To assess mobility in the work zone, field personnel must periodically measure actual travel time delay as identified in Chapter 13 Performance Measures, Project Level Measures. A sample data collection and analysis worksheet is shown in Table 13.1, titled Delay Worksheet. Each region is responsible for updating and maintaining this worksheet along with any supplemental information needed for their projects. The information contained in the Delay Worksheet will be utilized for evaluating project and program level effectiveness.

Work Zone Crash Evaluation
The process for compiling and analyzing work zone crash data is discussed in Chapter 8. It is each region's responsibility to retain the information, analysis and mitigation measures taken in the project files and in ProjectWise.

12.3 Using Work Zone Data at the Process-Level

At the process-level, the Work Zone Safety and Mobility Rule requires agencies to continually pursue improvement of work zone safety and mobility by analyzing work zone crash and operational data from multiple projects to improve agency processes and procedures. The same project-level data and information from multiple projects may be compiled and analyzed to identify trends and determine if there are common problems that could be remedied by a change in policy or practices. Work zone data may be used to conduct post-construction evaluations, support process reviews, develop lessons learned, and ultimately improve agency policies and procedures. This data and information typically becomes available during project implementation and it needs to be retained and maintained for post-construction analyses. Each region is to retain the necessary information utilizing ProjectWise. The information should include project contacts, supporting data, analysis techniques and results, work zone monitoring data work zone reviews, and other related information.

12.4 Maintaining Data and Information Resources

MDOT is required to maintain the data and information resources that are necessary to support the use and analysis of work zone data. Most of the data needed to conduct work zone performance monitoring during implementation as well as post-implementation assessments should be readily available from pre-existing sources. This data and information is to be managed in accordance with the MDOT Data Management Policy. The policy is under final development at this time. For information regarding the policy, contact BTP Asset Manager in the BTP, Asset Management Division.

Chapter 13 Performance Measures

Performance measures are evaluated to ensure successful implementation and continual improvement of MDOT's Work Zone Safety and Mobility Policy. The focus of these measures is on the delivery phase, and post-construction season evaluation.

At the program-level and project-level, two primary questions will be assessed at the end of each construction season:

- Are we meeting our goals?
- Did we establish the right goals?

The mobility analyses and post-season assessments described in this chapter will provide the basis for answering these two questions.

13.1 Biennial Process Review

On a biennial basis, a process review will also be conducted that includes an overall assessment of the policy. MDOT will conduct a review administered by the mobility committee to review the overall effectiveness of the Work Zone Safety and Mobility Policy. The mobility committee will review and document each region's implementation activities. The committee will also assess the uniformity of implementation across the regions on a statewide basis. Standardized performance factors will also be assessed and fine tuned to measure the percentage of projects in compliance with established thresholds.

The mobility committee will provide a report to the Chief Operations Officer on the compliance status of the mobility policy implementation with respect to the federal Work Zone Safety and Mobility Rule. Suggested improvements to the policy and revisions to the manual will also be included in the report.

The following are the general categories that should be monitored at both the program-level and project-level:

- Travel Time Delay and Associated Parameters
- Transportation Management Plan (TMP) Compliance
- Work Zone Safety Compliance
- Crash Data Evaluation
- Customer Feedback Evaluation

Performance measures are presented more specifically in this chapter depending on whether a high-level (program-level) assessment or a low-level (project-level) assessment is being conducted. Further, the above measures may be evaluated at different levels of

complexity depending on the nature of the roadway under construction. Roadway types are broken down as follows:

- Urban Freeway
- Rural Freeway
- Urban Arterial
- Rural Two-Lane

13.2 Program-Level Measures

Program-level accountability is essential for policy implementation and maintenance. The success of the Work Zone Safety and Mobility Policy implementation in each region will be evaluated on an annual basis by the Chief Operating Officer with support and advisement from the mobility committee and the safety and mobility peer teams. Program-level measures include evaluation of how many, or what percentage of, projects met the policy goals:

- **Travel Time Delay** – How many projects were able to meet the 10-minute work zone delay threshold
- **Transportation Management Plan** – How many projects were in substantial compliance with TMP requirements
- **Work Zone Compliance** – How many projects had satisfactory work zone safety reviews
- **Work Zone Crashes** – How many projects experienced an increase in crashes (and/or rates) during the project duration
- **Customer Feedback** – How many projects met the mobility needs of the customer

Results will help determine whether the travel time delay threshold appears to be an achievable objective for most projects. An important question is whether the customer's perception of what is tolerable generally matches this established threshold. The effectiveness of the policy itself will also be assessed and may be calibrated to what the motorist considers tolerable.

Travel Time Delay
Travel time delay is the most understandable parameter to the motorist and thus is considered the primary program-level measure with respect to achieving mobility goals. The other related parameters, volume to capacity ratio and level of service, will remain important variables in project significance determination and project level performance measures.

Tolerable delay within a work zone has been established as 10 minutes or less of additional travel time above normal conditions for any given timeframe for the segment of road under construction. The success of the Work Zone Safety and Mobility Policy depends directly on how often a motorist actually experiences work zone impacts that are considered unreasonable.

Travel Time Delay Performance Measure
At the region/TSC level, the number (or percentage) of projects that met the 10-minute threshold will be determined at the end of each construction season and presented to the Chief Operating Officer.

Transportation Management Plan
Compliance with the TMP requirements will be evaluated on a statewide level. Achieving work zone safety and mobility goals will be qualitative in nature, and will require discussion between the Chief Operating Officer and region engineers. The high impact presentations will be the forum to present and discuss development and implementation of TMPs. The safety and mobility peer team will also play an essential role in evaluating TMPs for those significant projects that can not be fully mitigated.

Transportation Management Plan Performance Measure
On an annual basis, the Chief Operations Officer and region engineers will review the projects where mobility threshold criteria were exceeded. The review is to include safety and mobility peer team activity for those projects. This assessment will be qualitative in nature.

Work Zone Compliance
Work zone reviews are to be conducted by central office, region and TSC personnel throughout the construction season. Review findings will be compiled on an annual basis by each region and submitted to the statewide work zone administrator for analysis on a statewide basis for submittal to the Chief Operations Officer. For each project review, a standardized checklist will be completed that will yield two primary determinations.

- Was the work zone in substantial compliance with the provisions of the TMP?
- If not, was corrective action taken in a timely fashion?

Work Zone Compliance Performance Measure
A summary of work zone review results will be provided to the Chief Operations Officer on an annual basis broken down by region. The summary will include the number of projects reviewed, the number (or percentage) of projects in compliance, the number of projects not in compliance that were brought into compliance in a timely fashion, and the number of non-compliant projects that remained non-compliant.

Work Zone Crash Evaluation Performance Measure
Each region will compile a summary report of work zone crash data for submittal to the statewide work zone administrator for analysis with the final report being submitted to the Chief Operations Officer. The summary will display the number (or percentage) of projects that showed an increase in crashes during construction from pre-construction conditions. Crash data from the period beginning on the start date of the construction project and ending on the completion date of the project will be compared to crash data from the exact same period the previous year. Injury crashes should be compared and

analyzed, in addition to total crashes. Analyses or assessments of any noticeable trends where crashes have increased for a particular group of projects should also be presented.

Customer Feedback and Perception
Public perception regarding how MDOT is doing as an agency in maintaining work zone mobility is difficult to quantify, but must continually be evaluated. This is accomplished through continual assessment of customer feedback from motorists, business owners, and local agencies during construction activities.

Although customer 'complaints' do not necessarily indicate a failure in achieving mobility goals, a pattern of inquiries may uncover elements in a work zone that warrants attention and potential action.

Although difficult to quantify, customer feedback is essential in measuring policy success, and vital for future project planning. At the program level, evaluation of public perception will be qualitative in nature through information sharing between region engineers and the Chief Operating Officer.

Customer feedback will also be essential for assessing whether the current mobility thresholds (e.g., the 10-minute delay) actually match what the motorist considers tolerable. An important question is whether the customer's perception of what is tolerable generally matches this established threshold of 10 minutes. The effectiveness of the policy itself will also be assessed and may be calibrated to what the motorist considers tolerable.

Customer Perception Performance Measure
On an annual basis, the Chief Operations Officer and the region engineers will review public perception information compiled on significant projects. This assessment will be qualitative in nature and based on observations and information obtained from MDOT staff at all levels.

13.3 Project-Level Measures

Project-level performance measures are summarized as follows:

Performance Measures	Roadway Type
Total Delay Field Measurements	Rural Frwy & 2-Lane
Delay, V/C, LOS Computations	Urban Frwy & Arterial
Total Delay Field Measurements	Urban Arterial
Work Zone Checklists	All
Traffic Crashes	All
Traffic Crash Rates	All
Public Feedback	All

Travel Time Delay

Travel time delay will be estimated for each potentially-significant project.
Actual delay measurements will serve two primary purposes:

1. Monitor and ensure that vehicle delays remain ten minutes or less. When delay is found to exceed this threshold, the engineer shall be notified, and mitigation measures shall be assessed and implemented where feasible.
2. Post-construction performance assessment. Actual delay times are to be compiled and compared to pre-construction estimates to see how close projections were and for purposes of improving future delay time projections.

For all potentially-significant projects, including those that are ultimately determined to be non-significant, actual travel time delays are to be periodically measured by field personnel during typical peak traffic periods. For rural freeway and two-lane projects, this is the primary method for assessing mobility during construction. A sample field data collection sheet is shown in Table 13.1. Some projects may require additional data collection to what is contained in Table 13.1.

For high-volume sections, traffic hose counts and/or portable traffic sensor devices can also be utilized for data collection. Actual travel time delay can be collected and assessed utilizing automated data collection (hose counts, traffic trailers) and through computations of V/C, LOS and delay. The drive-through is a good method to measure delay for higher volume roads.

REGION:	IN: TSC AREA	TSC INSPECTING:
PROJECT #:	HIGHWAY:	ORIGINAL DELAY ESTIMATE: MIN.

SKETCH:

DATE	TIME	DIRECTION	APPROX. MILE POINT	MILES OF SLOWDOWN*	MIN. SPENT IN SLOWDOWN**	PRE-CONSTRUCTION ZONE TRAVEL TIME AT POSTED SPEED LIMIT IN MINUTES ***	DELAY= DIFF. OF TIMES	MEASURED BY

NOTES RE: SPECIFIC CIRCUMSTANCE IN ABOVE OBSERVATIONS:

* FROM ODOMETER OR D.M.I. FROM INITIAL DECELERATION UNTIL POSTED SPEED RESUMED

** FROM STOPWATCH FOR ABOVE DISTANCE

*** $\frac{60 \text{ Minutes Per Hour}}{\text{Posted Speed Limit MPH}}$ X Miles of Slowdown = Minutes

Table 13.1 Delay Worksheet

Transportation Management Plan
Components of a TMP can vary greatly between projects in terms of what mitigation measures are implemented. Non-significant project TMPs may still include all the elements of a significant project TMP. Elements of a TMP will be documented in the development and delivery project files of each project. Summaries of TMPs will be presented at the annual high impact presentations and to the safety and mobility peer team as necessary by the appropriate region personnel.

Transportation Management Plans Performance Measure
The percentage of significant and non-significant projects that contained all required components of the TMP.

Work Zone Safety Compliance
A properly signed work zone is essential for motorist and worker safety, as well as mobility. Each project should be continually monitored by field inspectors, construction engineers, and traffic and safety engineers for items contained in the delivery safety checklist. The region/TSC traffic and safety engineer should periodically complete a formal work zone compliance review and submit the findings to the delivery engineer. The delivery engineer is to notify the contractor of any deficiencies for immediate corrective action.

Work Zone Compliance Performance Measure
Percentage of project construction files containing documentation of formal safety reviews.

Work Zone Crash Evaluation
If a traffic crash pattern has been identified in a construction work zone, mitigation measures are to be assessed and implemented where possible. Field personal should report any crash patterns observed to the engineer. The region traffic and safety engineer and TSC staff are to conduct an analysis of crash data including crash rates prior to the start of construction as well as during construction. This will require developing close working relationships with local law enforcement personnel.

Work Zone Crash Evaluation Performance Measure
Percentage of projects for which crash rates and patterns were monitored during construction and compared with pre construction crash rates.

Summary

Across the department there needs to be continual improvement in the tracking of mobility and safety effectiveness. Data collection techniques and measuring effectiveness is to be shared department wide through the mobility committee. Due to the potential volume of data and measurement techniques, efforts should be made to keep performance measures and related process and program reviews at an efficient and effective level.

Chapter 14 Local Agency Federal Aid Program

This chapter is reserved for future update. Local agency work zone safety and mobility program implementation will occur at a later date

Chapter 15 Training

Work zone related training is an important component in the work zone safety and mobility program. Federal regulations require that persons involved in implementing the Work Zone Mobility and Safety Policy be trained at a level consistent with their responsibility. Therefore, training will be required based on individual's role and responsibility in implementing the policy in Michigan. This includes all agency, consultant and contractor staff that is involved in implementing the policy.

The following table describes the type of training that is recommended to ensure that individuals have the appropriate background and tools to make decisions involved in the implementation of the Work Zone Safety and Mobility Policy.

Role/Responsibility	Mobility Process	Scoping Process	Development Process	Delivery Process	Crash Analysis	Capacity Analysis	Work Zone Design and Application	Traffic Regulator
Project Planning/ Scoping	X	X	X					
Operational Analysis	X	X	X		X	X		
Crash Analysis	X				X			
Work Zone Design	X	X	X	X			X	
CONSTRUCTION:								
Contractor	X		X	X	X		X	
Maintenance Field Staff	X						X	X
WORK ZONE INSPECTION:								
Construction Inspector	X		X	X	X		X	
Contractor Work Zone Supervisor	X		X	X	X		X	
Maintenance Supervisor	X			X			X	

Table 15.1 Training by Role and Responsibility

Mobility Process Overview

All individuals involved in the implementation of the policy should be trained in the mobility process overview. The department is developing this training module which will be available in the future. Until this module is available, training can be obtained by visiting the Florida Department of Transportation's online training module located at http://wbt.dot.state.fl.us/ois/UpdateTraining2007/Adams1.htm. . This link offers training in three modules.

Scoping, Development, and Delivery Process
As a result of the Work Zone Safety and Mobility Policy, several changes have been made to MDOT's processes in project scoping, development and delivery. Training modules are being developed in order to update staff on the new mobility requirements. These modules will be available in the future with online access for all MDOT employees. Until these modules are available, training can be accomplished by reviewing the process checklists found in Chapter 17.

Crash Analysis
Individuals involved with evaluating work zone safety are to be trained in interpreting crash reports, crash analysis, requirements of the Michigan Manual of Uniform Traffic Control Devices and in developing appropriate safety mitigation. This training requirement can be achieved through on-the-job training from MDOT qualified staff.

Capacity Analysis
Individuals involved in traffic analysis are to be trained in the procedures outlined in the Highway Capacity Manual, freeway and non-freeway capacity analysis, work zone capacity analysis, simulation tools and any other tools or techniques as appropriate. This training requirement can also be achieved through on-the-job training from MDOT qualified staff.

Work Zone Design and Application
This training can be satisfied by taking the 2-day MDOT course in "Highway Construction and Work Zones". This course provides staff with basic knowledge on work zone design and application with topics in planning work zone traffic control, work site traffic control devices, correct and incorrect applications of work site traffic controls, and proper procedures for operating and maintaining highway construction and work zones.

Traffic Regulator
Maintenance and construction staff that are involved in the application of work zones should be trained in how to properly control traffic through work zones. Currently, a course is being developed by MDOT. Until that time, all traffic regulators are responsible for following the procedures outlined in the MDOT "Traffic Regulators Instruction Manual" published by MDOT's Local Technical Assistance Program.

Additional Training
A list of MDOT, NHI and FHWA courses that are currently available is being developed and a link will be included in this chapter in the future.

Chapter 16 Best Practices

This chapter contains references for where to find the best practices used across the country for work zone safety and mobility management on construction projects. Best practices may be drawn from previously documented successes used throughout the state of Michigan, other state departments of transportation and through research conducted by FHWA.

This space in the manual will serve as a clearinghouse for posting of successful work zone management techniques, strategies, technologies and practices as they are delivered. Under the direction of the statewide mobility committee, this chapter will be considered a work-in-progress section of the Work Zone Safety and Mobility Manual. MDOT staff is encouraged to submit successful implementation practices to the statewide mobility committee through the region/central office representatives. Submittals will be reviewed and considered for inclusion into this chapter.

For research purposes, the following web sites have information specifically related to work zone operations or organizations and programs that address work zone safety and mobility issues. The Work Zone Safety Information Clearinghouse maintained by the Texas Transportation Institute is a particularly valuable source of current work zone information and contacts.

FHWA Work Zone Operations Best Practice Guidebook
http://ops.fhwa.dot.gov/wz/practices/practices.htm

American Road and Transportation Builders Association
www.artba-hq.org

American Traffic Safety Services Association
www.atssa.com

American General Contractors
www.agc.org

American Association of State Highway and Transportation Officials
www.aashto.org

Federal Highway Administration
www.fhwa.dot.gov

FHWA Highway Rail/Grade Crossing
http://safety.fhwa.dot.gov/safetyprogs/hiway/hiwaygradexing.htm

FHWA MUTCD web site
http://mutcd.fhwa.dot.gov

FHWA Work Zone Safety Program
http://safety.fhwa.dot.gov/safetyprogs/hiway/wkzone.htm

Institute of Transportation Engineers
http://www.ite.org

Local Transportation Assistance Program
http://www.ltap.org

National Utilities Contractors Association
http://www.nuca.com

Work Zone Safety Information Clearinghouse
http://wzsafety.tamu.edu

Chapter 17 Checklists

17.1 Project Scoping Checklist

1. Project Description

    - ☐ Route and local Name
    - ☐ Location (City, Township, Village, etc.)
    - ☐ Control section and job number
    - ☐ Point of beginning (POB) and point of ending (POE), station and description
    - ☐ Beginning and ending mile points
    - ☐ Type of work
    - ☐ Expected dates of construction
    - ☐ Brief project summary

2. Facility Description

    - ☐ Freeway or non-freeway
    - ☐ Corridor or site project
    - ☐ Grade (above, at, below)
    - ☐ Within boundary of a traffic operations center (MITS, West Michigan Traffic Management Center)
    - ☐ Primary adjacent zone classification (commercial, residential, historic, etc.)
    - ☐ Roadway separation and dimension (median, boulevard, non-divided, etc.)
    - ☐ Existing number of lanes per direction
    - ☐ Existing lane widths
    - ☐ Within 12 miles of adjacent region (ensure network and corridor analysis is completed across the regions, see item #9.)

3. Existing Capacity Analysis

    - ☐ Existing traffic volumes, ADT, DHV
    - ☐ Posted speed
    - ☐ Commercial percentage
    - ☐ Determine the existing volume to capacity (V/C) ratio for the project location during peak and non-peak travel times
    - ☐ Determine the existing average travel time for the project location during peak and non-peak travel times
    - ☐ Determine the existing level of service (LOS) for the project location during peak and non-peak travel times

4. Analyze the possible project fix types

5. Analyze the construction alternatives for the various project fix types (Chapter 6 in the Work Zone Safety and Mobility Manual)

6. Selection of the appropriate work zone (analyze the proposed project and construction alternatives)

    - ☐ Complete facility closure and detour
    - ☐ Long term stationary closures (lane, ramp, shoulder, etc.)
    - ☐ Short term stationary closures (lane, ramp, shoulder, etc.)
    - ☐ Flag control
    - ☐ Short duration
    - ☐ Mobile closures

7. Existing Operational Factors

    - ☐ Commercial/private access impacts
    - ☐ Emergency services access
    - ☐ Environmental issues
    - ☐ Geometric or lane conflicts
    - ☐ Local Agency Projects
    - ☐ Noise and/or work ordinance restrictions (local laws)
    - ☐ Over height clearance conflicts
    - ☐ Over wide clearance conflicts
    - ☐ Parking (on-street, access, etc.)
    - ☐ Pedestrian issues
    - ☐ Permitted activities
    - ☐ Railroad issues
    - ☐ Roadside conflicts or hazards
    - ☐ School bus/transit access
    - ☐ Special events
    - ☐ Traffic generators
    - ☐ Traffic signals
    - ☐ Transit issues
    - ☐ Utility issues

8. Proposed Capacity Analysis

- ☐ Work zone posted speed limit
- ☐ Proposed number of lanes per direction
- ☐ Proposed lane widths
- ☐ Determine the V/C ratio for the proposed temporary traffic control plan (TTCP) during peak and non-peak travel times
- ☐ Determine the average travel time for the proposed TTCP during peak and non-peak travel times
- ☐ Determine the LOS for the proposed TTCP during peak and non-peak travel times
- ☐ Determine the user delay and associated queues
- ☐ Determine if the proposed TTCP is non-significant or potentially significant
- ☐ If the proposed TTCP is potentially significant review and document mitigation strategies to minimize the expected delay (see chapter 5 in the Work Zone Safety and Mobility Manual for mitigation strategies)
- ☐ Estimate project costs and include all costs associated with the transportation management plan and mitigation strategies

9. Document Preliminary TMP

- ☐ Develop groundwork for the Temporary Traffic Control Plan (TTCP)
  - ☐ Dynamic lane merge system
  - ☐ Moveable temporary concrete barrier wall
  - ☐ Rumble strips
  - ☐ Temporary traffic signals
- ☐ Develop groundwork for the Traffic Operations Plan (TOP)
  - ☐ Bus/truck turnouts
  - ☐ Courtesy Patrol
  - ☐ High occupancy vehicle (HOV) lanes
  - ☐ Intelligent Transportation System (ITS) strategies
  - ☐ Intersection improvements
  - ☐ Park and ride promotion
  - ☐ Parking and/or turning restrictions
  - ☐ Police enforcement
  - ☐ Ramp metering
  - ☐ Reversible lanes
  - ☐ Ridesharing/Carpooling incentives
  - ☐ Shuttle services
  - ☐ Signal timing and coordination improvements
  - ☐ Transit incentives
  - ☐ Transit service improvements
  - ☐ Truck restrictions and/or separation
  - ☐ Variable work hours and/or shifts

- ☐ Develop groundwork for the Public Information Plan (PIP)
  - ☐ Brochures
  - ☐ Carpooling
  - ☐ Freight informational campaigns
  - ☐ Highway advisory radio (HAR)
  - ☐ Media exposure (television, radio, internet, etc.)
  - ☐ Park and Ride
  - ☐ Portable changeable message signs (PCMS)
  - ☐ Project stakeholder email distribution (staging, incidents, etc.)
  - ☐ Project website
  - ☐ Rideshare
  - ☐ Transit
  - ☐ Visor cards
- ☐ Document other pertinent information that might be useful to development, delivery, or contractor personnel

10. Region Level Review

- ☐ Analyze the project TMP with other regional projects within the corridor and network to maximize mobility within the region
- ☐ Analyze the project TMP with other network projects outside of the region to ensure mobility between regions and across the state
- ☐ Analyze the project TMP with other corridor projects outside of the region to ensure mobility between regions and across the state
- ☐ Document other corridor and network projects that may impact this project, include project and contact information

17.2 Project Development Checklist

1. Project information

    - ☐ Review project scope and description to ensure accuracy
    - ☐ Review existing volume to capacity (V/C) ratio for the project location during peak and non-peak travel times
    - ☐ Review the existing average travel time for the project location during peak and non-peak travel times
    - ☐ Review the existing level of service (LOS) for the project location during peak and non-peak travel times
    - ☐ Review project fix type and description
    - ☐ Review dates of construction
    - ☐ Review staging and constructability

2. Review and confirm existing operational factors

    - ☐ Commercial/private access impacts
    - ☐ Emergency services access
    - ☐ Environmental issues
    - ☐ Geometric or lane conflicts
    - ☐ Local Agency Projects
    - ☐ Noise and/or work ordinance restrictions (local laws)
    - ☐ Over height clearance conflicts
    - ☐ Over wide clearance conflicts
    - ☐ Parking (on-street, access, etc.)
    - ☐ Pedestrian issues
    - ☐ Permitted activities
    - ☐ Railroad issues
    - ☐ Roadside conflicts or hazards
    - ☐ School bus/transit access
    - ☐ Special events
    - ☐ Traffic generators
    - ☐ Traffic signals
    - ☐ Transit issues
    - ☐ Utility issues

3. Review and complete the proposed temporary traffic control plan (TTCP)

4. Review the proposed capacity analysis

    - ☐ Work zone posted speed limit
    - ☐ Proposed number of lanes per direction
    - ☐ Proposed lane widths
    - ☐ Review the V/C ratio for the proposed temporary traffic control plan (TTCP) during peak and non-peak travel times
    - ☐ Review the average travel time for the proposed TTCP during peak and non-peak travel times
    - ☐ Review the LOS for the proposed TTCP during peak and non-peak travel times
    - ☐ Review and confirm the user delay and associated queues

5. Final mobility analysis

    - ☐ Review and confirm the analysis for the determination of project mobility significance (significant or non-significant) for the proposed fix type and TTCP alternative

6. Significant projects

    - ☐ Design mitigation strategies to minimize expected impacts and delays
    - ☐ Refine and finalize the traffic operations plan (TOP)
    - ☐ Refine and finalize the public information plan (PIP)
    - ☐ Develop a suggested internal work zone traffic control plan for use by contractors for bidding purposes

7. Non-significant projects

    - ☐ Consider the use of a TOP
    - ☐ Consider the use of a PIP

8. Exceptions

    - ☐ Variations from the policy and manual are to be considered and evaluated on a case-by-case basis by a Safety and Mobility Peer Review Team
    - ☐ Final variation approval is obtained and documented from the region engineer and the Chief Operations Officer

17.3 Project Delivery Checklist

1. Project information

    - ☐ Review project fix type and description
    - ☐ Review dates of construction
    - ☐ Review the Transportation Management Plan (TMP)
    - ☐ Review project staging
    - ☐ Review project constructability

2. Review, understand, and note the impacts to existing operational factors within the project influence area and how the TMP proposes to address each issue

    - ☐ Commercial/private access impacts
    - ☐ Emergency services access
    - ☐ Environmental issues
    - ☐ Geometric or lane conflicts
    - ☐ Local Agency Projects
    - ☐ Noise and/or work ordinance restrictions (local laws)
    - ☐ Over height clearance conflicts
    - ☐ Over wide clearance conflicts
    - ☐ Parking (on-street, access, etc.)
    - ☐ Pedestrian issues
    - ☐ Permitted activities
    - ☐ Railroad issues
    - ☐ Roadside conflicts or hazards
    - ☐ School bus/transit access
    - ☐ Special events
    - ☐ Traffic generators
    - ☐ Traffic signals
    - ☐ Transit issues
    - ☐ Utility issues

3. Review the proposed temporary traffic control plan (TTCP) for each project stage

4. Work with the contractor and the TSC Traffic and Safety Engineer to understand the capacity analysis that has been performed for the proposed TTCP and how the staging plan affects these variables

    - ☐ Review the V/C ratio for the proposed temporary traffic control plan (TTCP) during peak and non-peak travel times
    - ☐ Review the average travel time for the proposed TTCP during peak and non-peak travel times
    - ☐ Review the LOS for the proposed TTCP during peak and non-peak travel times

5. Effectiveness of the TTCP and TOP

    - ☐ Understand how to monitor the effectiveness of the TTCP
    - ☐ Understand how to monitor the effectiveness of the TOP
    - ☐ Document the effectiveness of the TTCP
    - ☐ Document the effectiveness of the TOP
    - ☐ Review and document user delay and associated queues
    - ☐ Compile and review accidents within the work zone (MSP UD-10 form)
    - ☐ Compile and review accidents adjacent to the work zone (MSP UD-10 form)
    - ☐ If the TMP does not appear to be significantly functioning as planned or the expected outcomes vary considerably from TMP expectations engage the Work Zone Safety and Mobility Peer Review Team

6. Public information plan (PIP)

    - ☐ Understand the responsibilities for the successful implementation of the PIP
    - ☐ Ensure the utilization of the PIP
    - ☐ Document the relative effectiveness of the PIP

7. Work zone internal traffic control plan

    - ☐ Work with the contractor to develop and document a work zone internal traffic control plan to minimize delay and enhance work zone safety
    - ☐ Monitor the application of the work zone internal traffic control plan
    - ☐ Provide enhancement/adjustment suggestions and/or mandatory changes to the work zone internal traffic control plan
    - ☐ Document the work zone internal traffic control plan advantages and disadvantages

8. Significant projects
    - ☐ the Ensure that significant changes to the TMP are documented
    - ☐ Ensure that significant changes to the TMP include a revised mobility analysis which is required to document final work zone rule compliance

9. Exceptions
    - ☐ If problems or issues (multiple accidents, extended queues/delay, safety issues, etc.) are encountered during construction activities a Safety and Mobility Peer Review Team will be engaged to review project safety and mobility issues
    - ☐ Variations from the policy and manual are to be discussed with and approved by region engineer and the Chief Operations Officer

17.4 Peer Review - Development Documentation Checklist

1. Project information review

    - ☐ Project location, limits, and description
    - ☐ Existing capacity analysis
    - ☐ Existing volume to capacity (V/C) ratio for the project location during peak and non-peak travel times
    - ☐ Existing average travel time for the project location during peak and non-peak travel times
    - ☐ Existing level of service (LOS) for the project location during peak and non-peak travel times
    - ☐ Proposed project fix type and description
    - ☐ Proposed staging and constructability

2. Impacts to the existing operational factors

    - ☐ Commercial/private access impacts
    - ☐ Emergency services access
    - ☐ Environmental issues
    - ☐ Geometric or lane conflicts
    - ☐ Local Agency Projects
    - ☐ Noise and/or work ordinance restrictions (local laws)
    - ☐ Over height clearance conflicts
    - ☐ Over wide clearance conflicts
    - ☐ Parking (on-street, access, etc.)
    - ☐ Pedestrian issues
    - ☐ Permitted activities
    - ☐ Railroad issues
    - ☐ Roadside conflicts or hazards
    - ☐ School bus/transit access
    - ☐ Special events
    - ☐ Traffic generators
    - ☐ Traffic signals
    - ☐ Transit issues
    - ☐ Utility issues

3. Review the proposed temporary traffic control plan (TTCP)

4. Review the proposed capacity analysis

    - ☐ Proposed volume to capacity (V/C) ratio for the temporary traffic control plan (TTCP) during peak and non-peak travel times
    - ☐ Proposed average travel time for the TTCP during peak and non-peak travel times
    - ☐ Proposed LOS for the TTCP during peak and non-peak travel times
    - ☐ Proposed user delay and associated queues

5. Review the design mitigation strategies proposed to minimize expected delay

6. Review the proposed traffic operations plan (TOP)

7. Review the proposed public information plan (PIP)

8. Review the proposed work zone internal traffic control plan for use by contractors

9. Review the pre-construction crash data

10. Projects with similar characteristics

    - ☐ Review best practices from previous projects with similar characteristics
    - ☐ Review TTCP
    - ☐ Review TOP
    - ☐ Review PIP
    - ☐ Review crash patterns prior to construction
    - ☐ Review crash patterns during construction
    - ☐ Review mitigation strategies/techniques that were utilized
    - ☐ Review recorded/documented delay data from field observations after TMP implementation

17.5 Peer Review - Delivery Documentation Checklist

1. Project information review

    - ☐ Project location, limits, and description
    - ☐ Project fix type and description
    - ☐ Review the Transportation Management Plan (TMP)
    - ☐ Review the work zone internal traffic control plan
    - ☐ Review project staging

2. Project issues and/or incident review

    - ☐ Interview project delivery staff
    - ☐ Interview project contractor staff
    - ☐ Interview emergency management staff (police, fire, EMS, etc.)
    - ☐ Review the proposed temporary traffic control plan (TTCP) for the applicable project stage
    - ☐ Review the documented user delay and associated queues
    - ☐ Review any work zone pictures, videos, etc.
    - ☐ Review crash patterns prior to construction
    - ☐ Review crash patterns during construction
    - ☐ Review visibility/sight issues
    - ☐ Review project temporary signage, traffic control, and pavement markings
    - ☐ Review specific accidents within the work zone (MSP UD-10 forms)
    - ☐ Review specific accidents adjacent to the work zone (MSP UD-10 forms)
    - ☐ Review mitigation strategies and/or techniques that have been employed

3. Results and documentation

    - ☐ Provide final team recommendations to the statewide mobility team leader
    - ☐ Request performance documentation regarding any suggested and/or implemented changes
    - ☐ Request that all significant changes to the TMP are documented
    - ☐ Request that all significant changes to the TMP include a revised mobility analysis which is required to document final work zone rule compliance

17.6 Sample Transportation Management Plan Memo

A sample TMP memo is provided for guidance on the following pages.

MDOT Michigan Department of Transportation

OFFICE MEMORANDUM

DATE: January 26, 2008

TO: Art Green
Development Engineer
Grand Rapids Transportation Service Center

FROM: Paul Arends
Traffic and Safety Engineer
Grand Rapids Transportation Service Center Manager

SUBJECT: Transportation Management Plan
Job Number 82763
Control Section 41033, and 41051
M-37 (Alpine) over I-96 and M-44 (East Beltline) over I-96 and GTW Railroad
Joint Replacement, Deck Patching and Barrier Replacement
Kent County

Table of Contents:

I. Executive Summary: The proposed project consists of joint replacement, deck patching and barrier replacement on M-44 (East Beltline) over I-96 and the GTW Railroad and joint replacement on M-37 (Alpine) over I-96.

Project Data:

A. Letting date: February 1, 2008
B. Existing lane widths – see maintaining traffic sheets
C. Existing paved shoulder widths – see maintaining traffic sheets
D. Project Duration: September 3, 2008 to November 7, 2008
   - field work on M-44 starts September 3, 2008 and is continuous
   - field work on M-37 starts September 5, 2008 and is on weekends only
E. The Construction Congestion Cost (CO3) Program was used to calculate delay, backups and user costs. The detailed CO3 output is attached for review. Traffic volumes peak on these routes during summer weekday movements with Friday afternoons being the heaviest travel time. Weekend traffic volumes are significantly lower. All data used to calculate delay are from Friday afternoons after the Labor Day holiday. The traffic count data was

obtained from the web-based Traffic Monitoring Information System (TMIS).

Control Section, Roadway	**41033, Alpine**	**41051, East Beltline**
Road Type	6 lane arterial	5 lane arterial
Ex. Lane Configuration	2N, 3S, 1CLTL	2N, 2S, 1CLTL
Prop. Lane Configuration	2N, 2S, restricted turns	2N, 2S, restricted turns
ADT	52,700	43,200
% Commercial	3%	3%
Existing Hourly Capacity	2620	2900
Existing PHV	2838	2649
Existing PHV V/C	0.98	0.91
Existing PHV Timeframe	NB=6p, SB=3p	NB=6p, SB=9a
Proposed Hourly Capacity	2090	2192
Expected % Diversion	16%	22%
Proposed PHV	2925	2649
Proposed PHV V/C	1.50	1.33
Average Delay	4.1	5.6
Peak Hour Delay	15.5	21.5
Proposed Maximum Backup Length (Miles)	3.0	4.0
Existing Average LOS	B	A
Proposed Average LOS	C	C
Existing Peak Hour LOS	E	D
Proposed Peak Hour LOS	F	F
Project Significance Rating	Significant	Significant
Peer Team Review Needed	Yes	Yes

F. A crash analysis and safety review was conducted for each of the work zones. In order to be able to effectively monitor work zone crashes which may be experienced during construction, a baseline crash history was developed. To determine this, four years of crash data (2004-2007) between the proposed construction dates (September 3 – November 7) was analyzed. The analysis revealed the following **yearly average** crash experience.

Control Section	**41033, Alpine**	**41051, East Beltline**
Yearly Crashes	10.5	20
Minor Injuries	3.5	5.5
Serious Injuries / Fatalities	0.25	0
Rear End	6.5	15.25
Fixed Object	0.5	0
Head-On Left Turn	0.5	0.25
Angle	0.5	1.75
Sideswipe	2.0	0.75
Misc. Single Vehicle	0.5	0

Animal	0	1
Dual Right Turn	0	0.5
Dual Left Turn	0	0.25
Backing	0	0.25

Based on the current and proposed conditions, a detailed review of the crash data, and the lack of a correctable crash patterns, we do not expect crashes to increase during the project. This traffic configuration has been used on numerous other projects throughout the Grand Rapids TSC area. The most recent project was in 2006 on M-44 over the Grand River. During construction on this section of roadway, 1 lane of traffic was maintained in each direction, and left turn movements were limited. The crash rates on these projects have been analyzed and an increase in the crash rates did not result.

Crash data will be monitored while the TTCP and TOP are implemented to ensure that the work zone does not increase crash frequency. If crash frequencies increase, GRTSC personnel will make every effort to reduce crash potential by adjusting the TTCP and TOP to improve work zone safety and mobility.

Corridor and network traffic analysis were not conducted on this project because there are no other planned construction activities within the influence area of this project on state or local roadways.

II. Temporary Traffic Control Plan

The maintenance of traffic concept described herein recommends the use of the following measures to maximize work zone safety and minimize impacts on user mobility.

a. Lateral and longitudinal buffers will be provided during active work periods to maximize user mobility and worker safety.
b. The maintenance of traffic plan and typicals are attached.
c. The maintenance of traffic staging plan sheets are attached.
d. The Special Provision for Traffic Control Quality and Compliance is included in the proposal.

III. Transportation Operations Plan

The strategies for operations and management of the work zones are as follows:

a. The project is on an expedited schedule.
b. Detailed contractor work restrictions are listed in the maintenance of traffic plan and staging plan sheets.
b. The Special Provision for Accepted for Traffic Incentive is attached. The Department will pay a lump sum incentive of $100,000 if the project is accepted for traffic by 10-13-08.
c. Air and pedestrian traffic will not be affected by this project.
d. Work will be suspended during holiday periods as defined by the Project Engineer.

e. Portable changeable message signs, PCMS, will be used as described in the maintenance of traffic to warn traffic of upcoming work and changing traffic control during the life of the project. The PCMS will be installed and operational a minimum of 7 calendar days prior to the start of work.
f. Access for emergency management vehicles will be maintained at all times through coordination with MDOT construction staff.
g. Local law enforcement agencies will be asked to provide patrol of the work zones.
h. Work on Alpine Ave. will be restricted to weekend work in order to minimize impacts.
i. Turning movement within the work zone will be restricted in order to reduce side friction and maximize capacity.
j. Ramp access to and from the work zone will be restricted in order to reduce side friction and maximize capacity.

IV. Public Information Plan (PIP)

The following strategies will be utilized to keep the motoring public and stakeholders informed on the project.

a. Coordination has been completed with the Kent County Road Commission to ensure that access is maintained and parallel routes are free of construction activities.
b. A press release will be issued before the project begins detailing the project specifics, the maintenance of traffic plan and the project duration.
c. The MDOT lane closure data base will be updated.
d. The Grand Rapids TSC will send out periodic e-mails to law enforcement, emergency services, local agencies, local businesses and other contractors within the influence area of this project providing project update information.
e. PCMS will be used to warn traffic of upcoming work and changing traffic control during the life of the project. The PCMS will be installed and operational 7 calendar days prior to the start of work.
f. Existing DMS signs will be used to warn traffic of upcoming work and possible alternate routes.

V. Delay Calculation Details

See the attached sheets.

VI. Maintaining Traffic Plan Sheets

See the attached sheets.

VII. Vicinity Map

See the attached sheet.